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THE RELATION OF THE SPREAD OF INFECTION TO FASCIAL PLANES IN THE NECK AND THORAX

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IN A previous communication,[1] we have discussed the relation of the spread of infection of the lip and face to the fascial planes of those parts. In the face we described three muscular fascial spaces:—the space for the body of the mandible, the masticator space, and the parotid space, and one viscerovascular space, the pterygopharyngo-maxillary or the lateral pharyngeal space. We purpose here to describe the fascial spaces of the neck and thorax with special reference to the spread of infections in these regions. Due to the fact that many conflicting terms are applied to fasciae, we will, for the sake of clarity, repeat our previously expressed concept of types of fascial planes. Classified by their relation to the spread of infection, they are divided into two kinds, those associated with muscles and those surrounding viscera and vessels. The muscular fascial planes are always ultimately inserted into bone, thereby sharply limiting infections in these spaces. The viscerovascular fascial spaces extend along vessels and viscera in continuity with these structures, thereby allowing infection in them to pass readily from one region to another.

In the neck there are certain definite fascial planes of both sorts. After the skin, subcutaneous tissue, and platysma muscle have been reflected, we find the first muscular fascial plane of the neck enclosing the sternocleidomastoid and trapezius muscles. This fascia, shown in Fig. 1, is continuous above with the muscular fascial boundaries of the masticator space and extends downward to blend with the periosteum of the clavicle and sternum, corresponding with the muscular fascial plane of the pectoralis major muscle below the clavicle. Internal to this plane is found the second muscular fascial plane (shown in Fig. 2) in which lie the sternohyoid and omohyoid muscles. Above, it joins

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the first layer of fascia at the hyoid base to form the fused fascia, and below, at the superior surface of the sternum, it splits in two layers to form the suprasternal space, blending below with the periosteum of the anterior and posterior aspects of this bone. Lateral to this point the inferior border of the plane blends with the periosteum of the posterior border of the clavicle and with the upper border of the scapula where the omohyoid muscle is inserted. The lateral boundary of this plane continues around the neck between the trapezius and the deep

Fig. 1.—Dissection demonstrating the first muscular facial plane. (*A*) Sternocleidomastoideus with the first muscular fascial plane of the neck. (*B*) Pectoralis major at the same plane.

muscles of the neck to insert into the ligamentum nuchae. In its lower portion below the point of perforation by the external jugular vein, it ends in the fascia surrounding this vein. The suprasternal space shown in Fig. 3 contains lymph nodes, lymphatics, and the vein, making an anastomosis between the anterior jugular veins. This space may be infected indirectly by infection carried through the lymphatics or directly from osteomyelitis of the sternum. Between the first and second planes above described is a definite space of importance to the surgeon in his dissection, but of no important clinical significance, as it is rarely

if ever the site of infection. The third muscular fascial layer is composed of the fascia enclosing the sternothyroid and the thyrohyoid muscles continuing above to the hyoid bone. The lateral boundary of this layer fuses with the fascial sheath of the internal jugular vein, while inferiorly it is attached to the posterior border of the manubrium and the first rib. Between the second and third fascial planes is a space that is seldom infected. It has some importance to the surgeon, however, in

Fig. 2.—Dissection of the first muscular fascial plane (*A*), second muscular fascial plane (*B*), and fused fascia (*C*).

that by following this space laterally he will meet the internal jugular vein. These planes are shown in sagittal and cross-section in Figs. 3 and 4.

THE VISCEROVASCULAR SYSTEM

Thus far we have described layers of fascia that have originated from some part of the face and neck and have been inserted into some aspect of the upper portion of the bony wall of the thorax. We now

come to the highly important fascial compartment that extends from the skull to the fibrous portion of the pericardium in a cylindrical shape, enclosing the posterior and lateral walls of the pharynx, the ascending aorta, arch of the aorta, the subclavian and carotid artery and its branches, the internal jugular vein, the vagus and cervical sympathetics, the hypoglossal and spinal accessory nerves, and the submaxillary, thyroid, and thymus glands, the larynx, trachea, and esophagus.

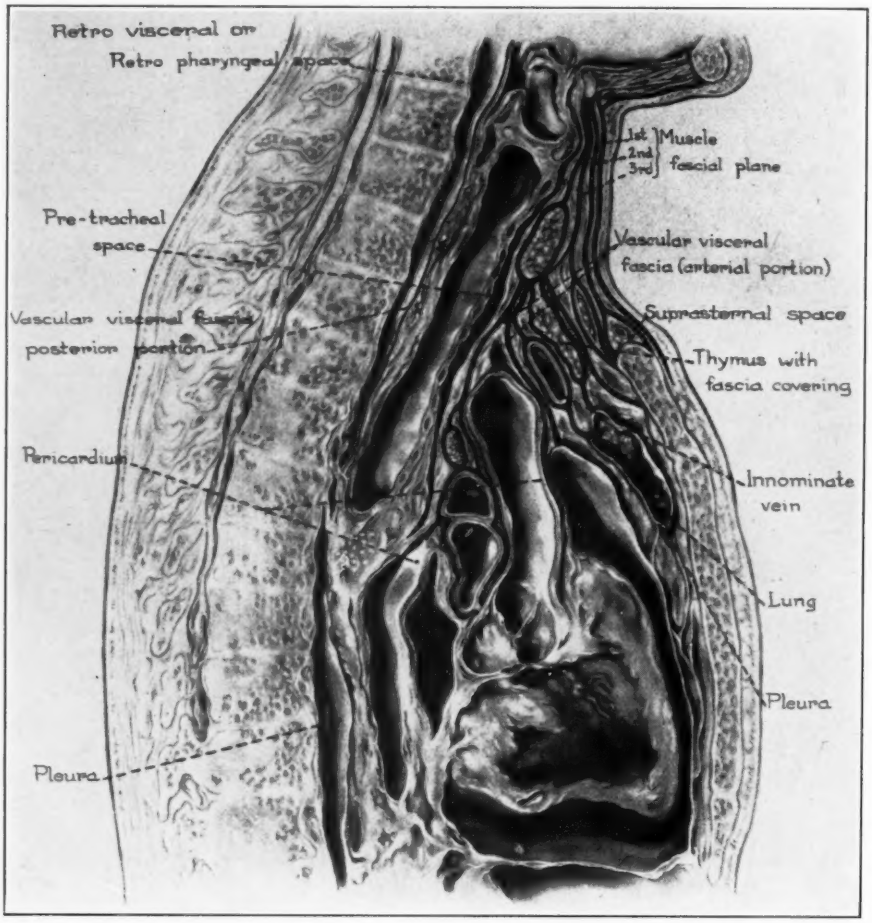

Fig. 3.—Sagittal section through neck and thorax showing fascial planes and spaces. (Drawing from dissection by the authors.)

This large space enclosed by the viscerovascular fascia is of the greatest importance to the surgeon since it connects the mouth, throat, and pharynx with the mediastinum through the neck and is the route along which infections commonly pass. For its clear understanding, on anatomic grounds and also because of the different clinical problems involved, we will discuss the various subdivisions of this huge space.

The portion of this system of fascia that lies posterior to the pharynx has been called the buccopharyngeal fascia, that layer lying anterior

to the trachea called the pretracheal fascia, and that portion surrounding the aorta and its branches called the vascular sheath. All of these fascial planes have usually been described as separate entities, but as shown in our dissection, they form subdivisions of this one large system of viscerovascular fascia.

The lateral pharyngeal space, previously described,[1] located between the lateral wall of the pharynx and the medial wall of the masticator and parotid spaces, lies closely related on its posterior wall with the internal carotid artery and the internal jugular vein. This space may be infected from the pharynx, and from the three important fascial spaces of the face, thereby acting as a portal of entry from all of these spaces to the large viscerovascular space or one of its subdivisions.

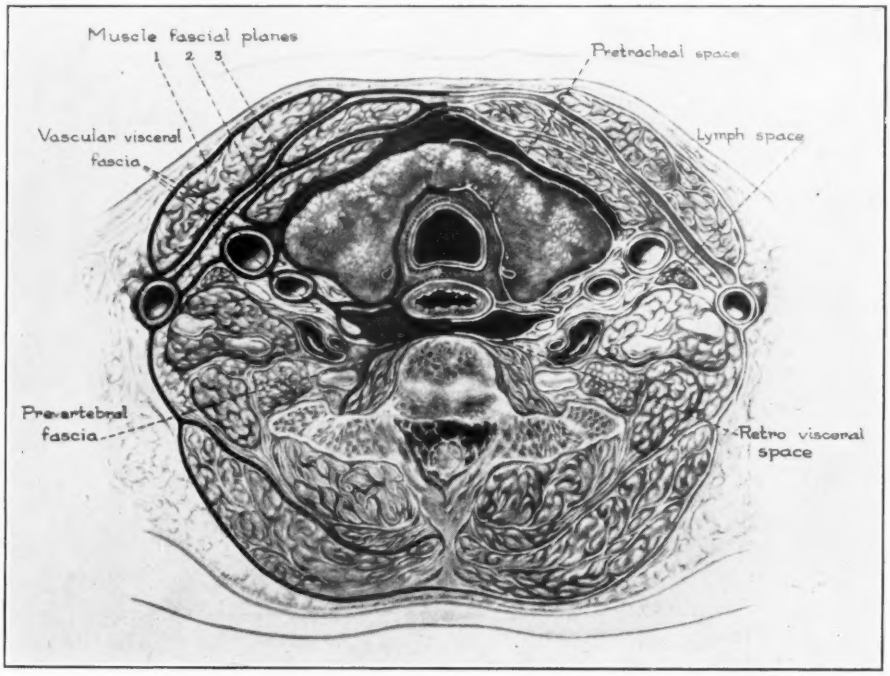

Fig. 4.—Horizontal section at the neck showing dissection of the fascial planes and spaces. (Drawing from dissection by the authors.)

SPACE OF THE SUBMAXILLARY GLAND

The submaxillary gland is enclosed by that portion of the viscerovascular fascia that surrounds the pharynx and covers the floor of the mouth. This gland with its fascial covering is separated from the parotid space and subcutaneous tissue by that part of the first and second muscular fascial planes of the neck called the fused fascia. The anterior belly of the digastric muscle and intermediary tendon and the insertion of the second muscular fascial plane to the hyoid bone act as a limiting wall below, to infection arising in the gland. These relations are well shown in Figs. 5 and 6. Posteriorly the fascial cover-

ing of the gland is connected to the external carotid sheath and forms the floor of the lateral pharyngeal space. In both situations, neglected infections may perforate and thus infect the viscerovascular space. There are in the submaxillary space, lymph nodes that communicate with the lymphatics of the mandible and the floor of the mouth. The space may therefore be infected either through the submaxillary duct from the mouth, often associated with the presence of calculi, this being a true infection of the submaxillary gland; or it may be infected sec-

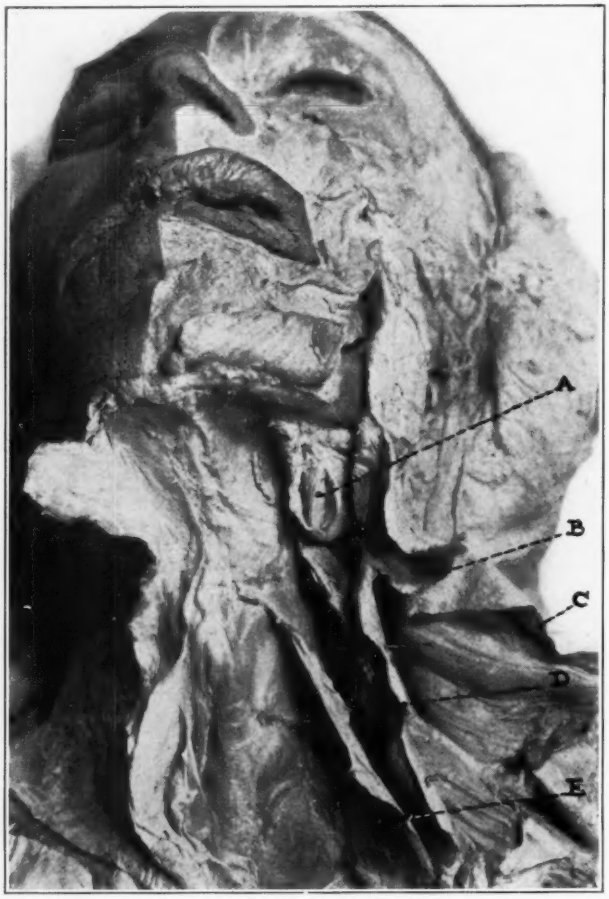

Fig. 5.—Dissection showing the submaxillary gland with the fascial covering (*A*); (*B*), fused fascia; (*C, D, E*), first, second, and third fascial planes.

ondarily from infection of the lymph nodes contained in it. Infection here manifests itself commonly as a swelling below and anterior to the angle of the jaw and should be differentiated from Ludwig's angina, which is an infection of the intermuscular and sublingual spaces in the floor of the mouth with its chief swelling adjacent the midline. Both the submaxillary and sublingual spaces may be infected simultaneously through the lymphatics or by anatomic continuity along the duct as it passes between the myelohyoid and the hyoglossus muscles.

Infection in the space of the submaxillary gland can be drained through an incision made parallel to the lower border of the body of the mandible and about 1.5 cm. below it. The incision is carried directly through the skin and platysma and the fused fascia to the gland. Excision of the gland often offers the best drainage and is the procedure of choice if the gland is even partially destroyed by the infection. Drainage of the lateral pharyngeal space may likewise be carried out through the same skin incision. Mosher[2] has advocated drainage of the lateral pharyngeal space by turning the submaxillary gland upward, but as seen in Fig. 6, the lateral pharyngeal space can be reached more simply by carrying the dissection upward and posterior to the gland,

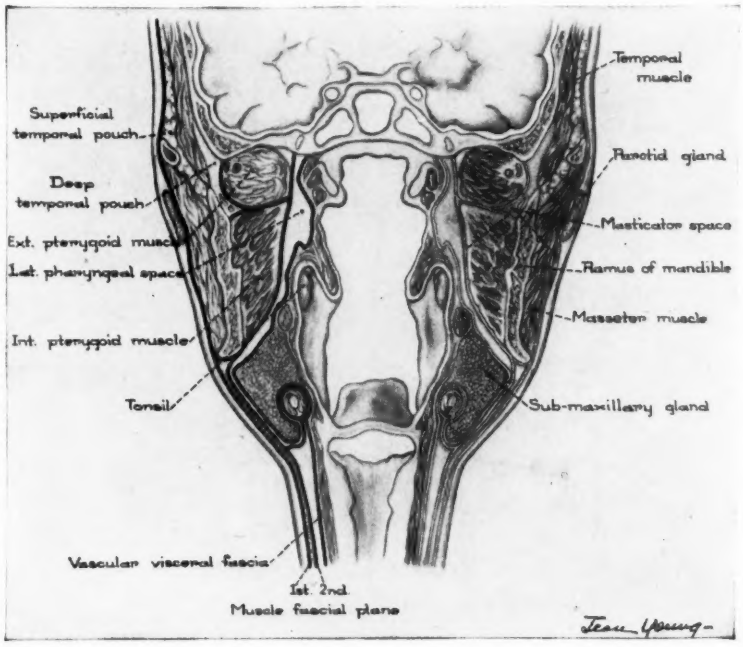

Fig. 6.—Frontal section demonstrating the different fascial planes and potential anatomic spaces. (Drawings from dissection by authors.) (This figure is taken from the article "Infections of the Lip and Face," Surg., Gynec. & Obst. 60: 277-290, 1935.)

passing between the gland and the internal pterygoid muscles. As mentioned in a previous article,[1] the lateral pharyngeal space may also be easily reached by a dissection passing posterior to the deep portion of the parotid and anterior to the external carotid artery.

PRETRACHEAL SPACE

The fascia from the submaxillary region is continued downward, to surround the larynx below which it encloses the thyroid gland and its arteries. The superficial leaf covering the anterior surface of the thyroid gland is separated from the third muscular fascial plane by loose areolar tissue, a line of cleavage utilized by surgeons in exposing

the thyroid gland. (See Figs. 3 and 4.) The deep leaf of this fascia on the posterior wall of the thyroid gland is intimately connected with the true carotid sheath laterally, and from here passes mesially and downward to surround the trachea and esophagus ending below in the fibrous pericardium, enclosing between its layers the aorta and its branches, thus forming this previsceral portion of the viscerovascular system of fascia. Between this previsceral portion and the trachea and

Fig. 7.—Lateral x-ray of injection of the pretracheal (*B*) and lateral pharyngeal space (*A*). Lateral pharyngeal injection is lying in front of the trachea and behind the sternum, and the close proximity of the injection of the lateral pharyngeal and pretracheal can be seen.

esophagus, lying posterior to it is a potential space known as the previsceral or pretracheal space. This space is partially obliterated at the level of the isthmus of the thyroid by a close areolar attachment of the isthmus to the larynx, and is continuous upward between the walls of the larynx and pharynx and the adjacent viscerovascular fascia. It extends below around the trachea to the point of fusion of these fasciae to the pericardium. Figs. 7 and 8 show roentgen rays of injec-

tion of the pretracheal space by an opaque substance below the level of the thyroid. The space is seen to be limited below by the pericardium and above by the superior attachments of the thyroid. Infections arising from the lateral wall of the pharynx such as a peritonsillar abscess or infection of the lateral pharyngeal space may extend down to infect this entire pretracheal space. Infections may also reach it from perforation of the anterior wall of the esophagus. This pathway for the spread of infection must be differentiated from that of the carotid and

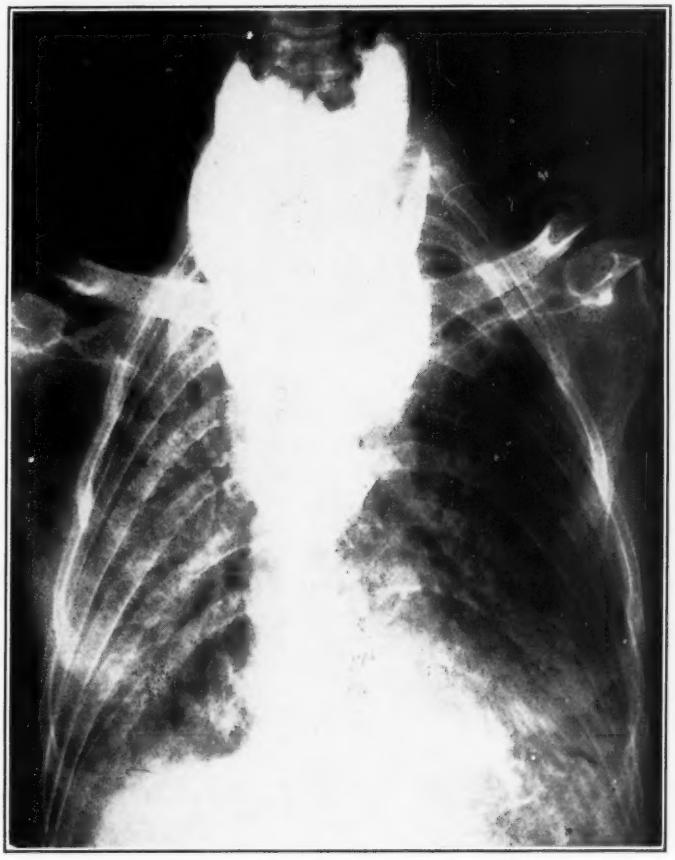

Fig. 8.—Frontal x-ray of injection of the pretracheal space.

juglar sheath which lies lateral to it. That portion of the viscerovascular fascia surrounding the carotid artery and jugular vein forms the true sheath for these vessels and may be infected from the lateral pharyngeal space directly, but if this occurs, the infection remains limited to this sheath. Infection of the carotid sheath is not common, only accompanying thrombosis of the internal jugular vein. That division of the viscerovascular fascia thus described dealt with that portion of it enclosing the ascending aorta, the arch of the aorta, and the subclavian and carotid arteries, being eventually fixed to the fibrous

pericardium. Anterior to this and below the thyroid is another subdivision of the viscerovascular fascia of lesser surgical interest. Two compartments are formed as shown in Fig. 3. In the posterior lie the innominate veins and superior vena cava, and in the second just anterior is the thymus gland. Both of these fascial planes terminate below by fixation to the pleura. Between the fascia covering the great veins and that covering the arteries, as well as between the mediastinal pleura and the pericardium, lies a potential space, the pleuropericardial space. Infection of this space occurs in association with infections spreading down the sheath of the internal jugular vein and the carotid artery, but as a late manifestation of the process.

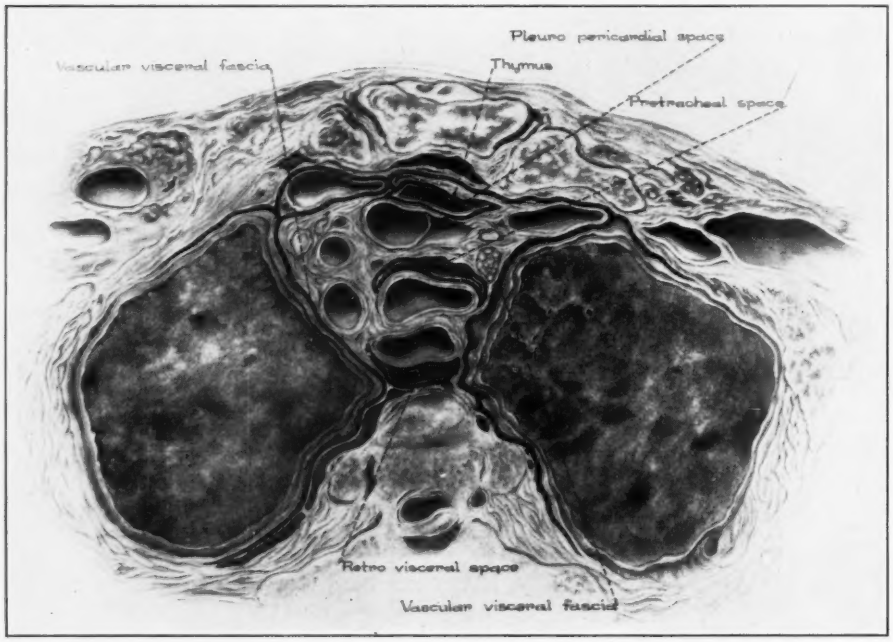

Fig. 9.—Horizontal section at the upper portion of the thorax showing the dissection of the fascial planes and spaces. (Drawing from dissection by the authors.)

RETROVISCERAL SPACE

The fascia that covers the posterior wall of the pharynx and esophagus is the retrovisceral portion of the viscerovascular system. Between this and the prevertebral fascia is a large and important space bounded laterally in the neck by the fusing of these fasciae at the point where they surround the cervical sympathetic chain. Above, it extends to the basilar process of the skull and is continuous below to the diaphragm. In the thorax, as shown in Figs. 3 and 9, the lateral boundaries are formed by the expansion of the sheath covering the descending aorta as it passes posterior to the parietal pleura to join the posterior wall of the thorax. Below the level of the bifurcation

of the trachea, the space becomes very small and may be entirely occluded at that level by the close approximation of the two pleurae. The space designated as the retrovisceral space is also known as the retropharyngeal or the prevertebral space. A lateral view of an opaque injection of this space is shown in Fig. 10.

Infections of the retropharyngeal space from the neck will descend with ease to this point, that is, at the bifurcation of the trachea, but

Fig. 10.—Lateral x-ray of injection of the retropharyngeal space (*A*) located posterior to the trachea (*B*).

may be stopped here by the obliteration of the space by the approximation of the pleurae at this point. Infections of the retropharyngeal space below this level are always secondary to lesions of the vertebrae and the ribs and by perforation of the esophagus below this level.

As shown in Fig. 3, any perforation of the esophagus in the posterior half of its wall may cause an infection of the retropharyngeal space. The retropharyngeal group of lymphatic nodes in this space may be infected secondary to primary infection arising in the ear, nose, throat,

or sinuses. Infection, either pyogenic or tuberculous, arising from any bone adjacent to this space, including the basilar process of the skull, the petrous portion of the temporal bone, the cervical and dorsal vertebrae, and the posterior ends of the ribs, may spread to the space. Infections in any of the cervical and the upper dorsal vertebrae will first produce a prevertebral abscess that is limited by the prevertebral fascia, muscles, and ligaments, and will remain localized there for varying lengths of time. Eventually perforation of the prevertebral fascia will take place, thus infecting secondarily the retrovisceral space. Infections in the lower dorsal and the first and second lumbar vertebrae will first be limited by the ligaments and the prevertebral fascia, but ultimately will perforate and spread to the lower portion of the retrovisceral space and tend to expand laterally between the pleurae and the expansion of the aortic sheath as it attaches to the thoracic wall. If infection originates in the posterior end of the ribs, the spread of the infection will be in a reverse direction from the ribs along the space between the pleura and the lateral expansion of the sheath of the descending aorta to the retrovisceral space. For these reasons, infections in the retrovisceral space above the fourth dorsal vertebra may best be drained by an incision in its upper portion in the neck, and infections below this point must be drained directly by posterior rib resection. Clinically this abscess will give rise to a variety of well-known signs and symptoms, depending upon its point of origin. After pus has entered the space, there will be dysphagia, dyspnea, and dysphonia, and examination will show a bulging of the posterior pharyngeal wall. In infants and young children, the chief symptom will be dyspnea, since the posterior wall of the trachea is less fixed and more compressible than is the trachea of an adult. In adults, the trachea is less easily compressed, and the chief symptom will be dysphagia due to compression of the esophagus. Roentgen ray examination will show an increase in the width of the retropharyngeal space in both the frontal and lateral projections.

Drainage of infection in the space may be carried out through an incision made along the anterior border of the sternocleidomastoid muscle at any desired level between the hyoid bone and the sternum, depending upon the level of the infection. After division of the skin, subcutaneous tissues, and platysma muscle, the first muscular fascial plane is divided along the anterior border of the sternocleidomastoid muscle, and this muscle is retracted laterally; the second muscular fascial plane is divided along the lateral border of the omohyoid muscle, and the third muscular fascial plane is incised and separated from the sheath of the internal jugular vein. The lateral or lower border of the thyroid gland is lifted and at the lower border of the thyroid is encountered the fascia passing from the lower border of the thyroid gland to the venous portion of the viscerovascular fascia and to the thymus gland.

After incising this fascia, we enter the upper portion of the pleuropericardial space, accomplishing now its drainage. Passing deeper, the pretracheal fascia may be incised, thus opening the pretracheal space. This same incision can be used for drainage of the retropharyngeal and vascular sheath in the following way if one desires: After passing through the third muscular fascial plane, the vascular sheath may be opened and thus drained. By following anterior to this sheath, the visceral portion of the viscerovascular fascia is divided along the lateral border of the esophagus, thus entering into the retropharyngeal space. Furstenberg[3] has advocated drainage by this method on the right side, since the esophagus lies to the left of the median line, because of the greater number of lymph nodes on the right, and because of the farther

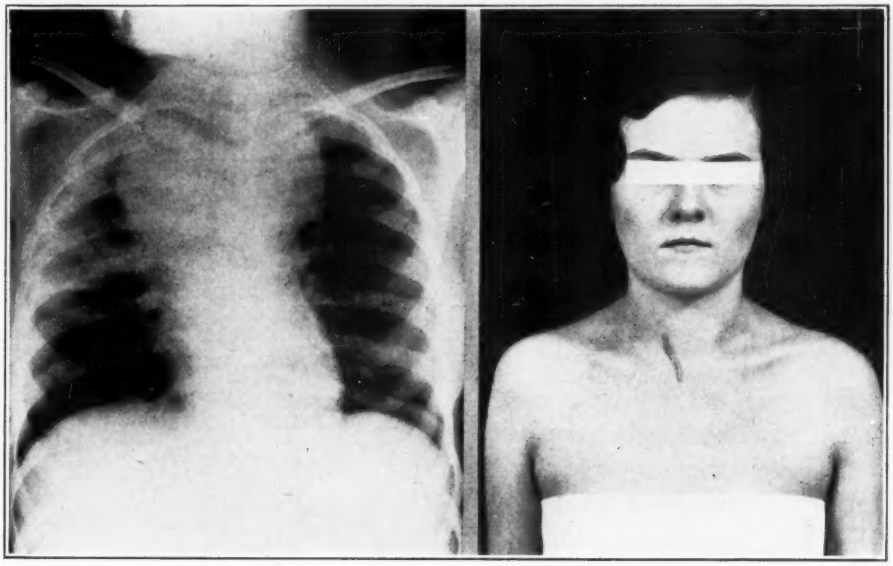

Fig. 11.—X-ray and photograph of a case of an abscess of the retrovisceral space at the superior portion of the thorax in which cervical drainage was done. (Courtesy of Dr. John Alexander.)

divergence of the right pleura from the median line, and the larger size of the space on the right. The retropharyngeal space may perhaps better be drained through an incision made posterior to the sternocleidomastoid muscle, by carrying the dissection through the first and second muscular planes, entering into the lymphatic space of the neck posterior to the jugular vein and carotid artery. The fascial expansion that includes the cervical sympathetic chain can be divided, and the retropharyngeal space entered and drained. This incision has a distinct advantage for drainage of this space alone, in that no other spaces of the neck are opened, and all drains are posterior to and not directly against the large vessels of the neck. An objection often advanced against this incision is that the sympathetic nerve may be injured, but we feel that there is very little chance of this, if the dissection is prop-

erly carried out, the dissection being effected in a vertical direction parallel to the direction of the nerve. Naturally early infection of this space originating from its upper portion and presenting in the posterior wall of the pharynx will first be drained by the time-honored method of direct incision at the site of the presenting tumor of the pharynx. If, however, the infection has passed to or originated in the lower portion of this space below the fourth cervical vertebra, drainage will probably be necessarily carried out by external thoracotomy. The site of election is determined by study of the lesion by x-ray, and a segment of a rib (or ribs) at the appropriate level on the prominent side is resected through a hockey-stick shaped skin incision. The internal periosteum is divided, and the wall of the abscess encountered and opened. The incision must be carried out as far mesially as possible.

The final space in the neck, of importance to the surgeon from its relation to infection, is that associated with the lymphatic chains. There are in general two groups of these lymph nodes shown in Fig. 4, one superficial, lying under the platysma muscle along the external jugular vein. These glands are often infected, but only produce localized subcutaneous abscesses and do not communicate with other fascial spaces in the neck. The second or deep group, however, lie in a space along the great vessels; the upper groups of these have already been mentioned in our previous article.[1] These lymph nodes lie in a triangular space bounded anteriorly by the sheath of the internal jugular vein and the common carotid artery; posteriorly, by the fascia covering the scalenus anticus muscle, the base of the triangle, being external, formed by the fascia connecting the internal and external jugular veins. The space extends upward to the mastoid and continues downward to the supraclavicular fossa. Here the lymphatic nodes end in the angle between the subclavian and internal jugular veins. The base of the supraclavicular fossa forms the apex of the axilla, being penetrated by the subclavian vessels. Infection extending down along this chain of nodes may pass directly to the axilla. The lymph nodes may be involved by an infection originating in the face, lips, mouth, tonsils, pharynx, or esophagus. When drainage becomes necessary, these lymphatics may be reached by the first stage of an incision previously described, made along the posterior border of the sternocleidomastoid muscle.

To summarize, we have described three spaces in the neck, lying between muscular fascial planes, that are limited by bony attachments above in the face, and below to the thoracic cage. Infections in these are infrequent and are limited sharply to the neck. Between these spaces and the prevertebral muscular fascia lies a large viscerovascular system of fascia in which we have described the presence of four definite fascial compartments and a vascular sheath. The lateral pharyngeal space is a receiving station for infections arising from fascial spaces

in the face and pharynx, from which infection in turn may pass to all other compartments of the viscerovascular system. Two other compartments, the pretracheal and the retrovisceral, pass directly into the thorax. Infections passing along the sheath of the vessels will likewise pass directly to the thorax.

The mediastinum may be very simply divided into compartments if the above facts are borne in mind. Immediately behind the sternum is the space commonly called the anterior mediastinum, that is, a retrosternal space occupied by a few lymphatics, fat, and areolar tissue. It is bounded posteriorly by the pleurae and the fascia connecting them. It is of no surgical importance except in association with trauma and infection arising in the sternum. Posterior to this in its upper portion lie the thymus and innominate veins with their fascial covering walling off the upper part of the retrosternal space from the neck. Behind this, we come to the space lying between the pleura and pericardium, the pleuropericardial space, that may be infected from the vascular sheath or from the pretracheal space. Posterior to this space are the ascending aorta and the arch of the aorta with their sheaths. Behind them lie the pretracheal space and just behind this the retrovisceral space, both of supreme importance because they are the major pathways for the entrance of infection to the thorax.

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AN ASEPTIC TECHNIC APPLICABLE TO GASTROJEJUNOCOLIC FISTULA

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THE importance of avoiding gross contamination in surgery of the bowel has been evident since such operations were undertaken, peritonitis having been the most common cause of failure. To be sure, the peritoneum will withstand a great deal of infection, more in fact than most of the body tissues. Thus, gross soiling by intestinal contents at the time of operation will often fail to produce a fatal peritonitis. A constant or recurring insult such as that afforded by a leaking suture line will, on the other hand, almost invariably result fatally.

In the effort to avoid frank contamination, there have been many ingenious methods of so-called aseptic anastomoses devised. This has resulted in a greatly reduced mortality in intestinal surgery and has actually taken away so much of the hazard that these operations are undertaken with increasingly greater confidence as to the outcome. The evidence is such that one can offer no plausible excuse for any surgeon who fails to make use of one of these procedures. Perhaps he may prefer some modification which appeals to him as more logical or which suits his particular style of surgical technic. The fact remains, however, that complete disregard of some comparatively aseptic method of handling bowel suture, whether this be on the basis of more accurate approximation, fear of adequate blood supply, or any other argument, is absolutely unjustified. We have found Kerr's[1] technic, slightly modified, eminently successful after an extensive trial over a period of more than ten years.

Gastrojejunocolic fistula is fortunately a comparatively rare situation. It does occur, however, with sufficient frequency to offer one of the most trying problems with which the surgeon is forced to deal. Spontaneous fistulas may occur between the stomach and bowel or between the high small intestine and large bowel. These are usually based on carcinoma of the stomach with adherence and secondary involvement of the transverse colon with occasional erosion between these two structures. The reverse of this sequence is also possible. The majority of such fistulas, however, come about following the development of a marginal ulcer at the stoma of a previously made surgical anastomosis between the jejunum and the stomach. These marginal, stomal, or gastrojejunal ulcers do not all produce sufficient in-

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flammatory reaction to involve the colon to a point of actual penetration. In 1933, Benedict[2] in our clinic collected thirty-six gastrojejunal ulcers. Twenty-one of these were proved at operation and represented an incidence of 2.9 per cent. Adding fifteen x-ray and clinically diagnosed cases, the incidence is nearly 5 per cent in gastroenterostomies for duodenal ulcer in our hospital. No case of gastrojejunal ulcer followed gastroenterostomy for gastric ulcer during this period of

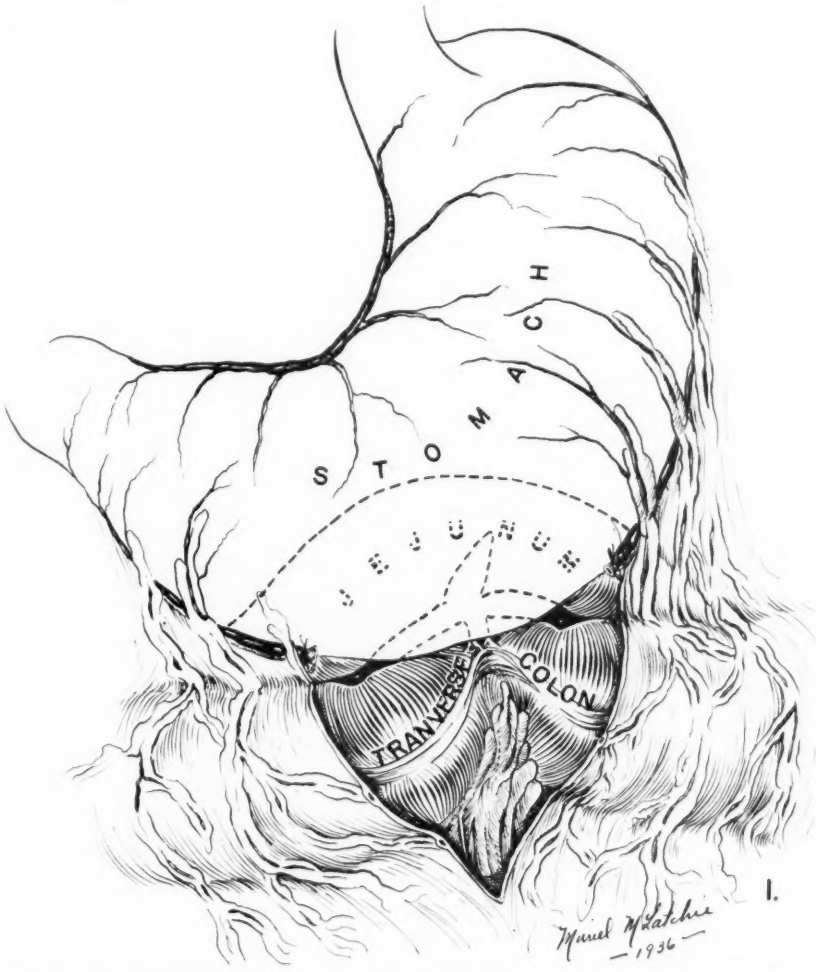

Fig. 1.—Schematic drawing representing condition found at operation. The vessels along the greater curvature of the stomach have been divided, and the gastrocolic omentum separated so that the lesion could be developed.

time. Five of these gastrojejunal ulcers were complicated by gastrojejunocolic fistulas, an incidence in this series of 23.8 per cent of the cases proved at operation, or 13.9 per cent of the entire group. Since this publication, we have treated five additional cases of gastrojejunocolic fistula following gastroenterostomy for duodenal ulcer, making a total of ten cases to date.

During this same period of time, four gastrocolic fistulas spontaneously developing as a complication to carcinoma of the stomach or transverse colon have been observed. These will not be considered further in this report.

Eight of the ten gastrojejunocolic fistulas, subsequent to operations for duodenal ulcer, were subjected to radical operation. Two of these died of general peritonitis following a resection of the fistula and restoration of normal continuity. Six survived the operation. Four had resection of the stomach with Polya anastomosis at the same time.

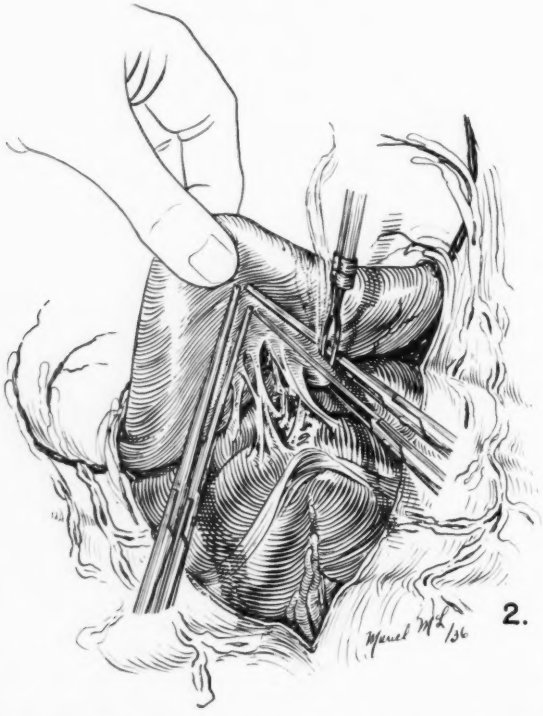

Fig. 2.—After freeing the greater curvature of the stomach and minor adhesions about the fistula, four long thin Kocher clamps have been applied about the stomach side of the stoma. This wedge-shaped section is freed by the actual cautery.

One had resection for recurrent duodenal ulcer with massive hemorrhage thirteen months following excision of his gastrojejunocolic fistula and restoration of normal continuity. One is now symptom-free on a six meal bland diet four months after operation. (Case reported below, in detail.) It seems to be the rule for these patients to reactivate their duodenal ulcers if normal continuity is restored, so that this last patient will probably need partial gastrectomy at a later date, bearing in mind the likelihood that a logical physiologic control of all peptic ulcers will be discovered prior to the necessity of this crude and not perfectly satisfactory method of dealing with such

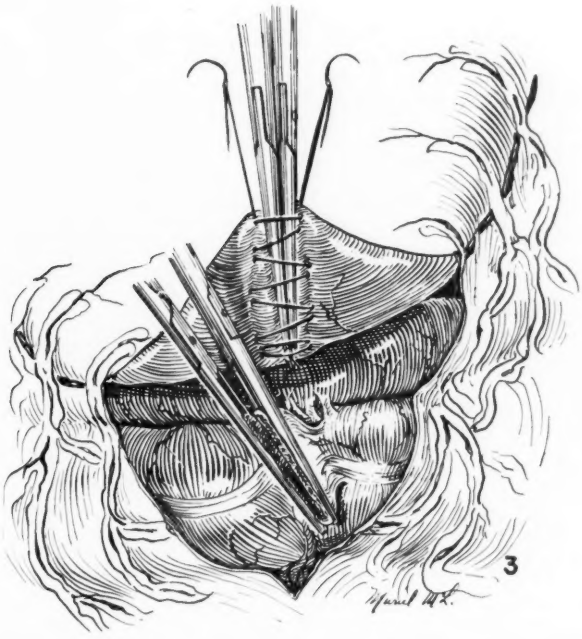

Fig. 3.—The stomach defect is being closed by continuous catgut sutures, one on the anterior surface and one on the posterior surface of the stomach. While these are drawn taut, the clamps are slipped out. A second row of sutures reenforces the opening in the stomach wall.

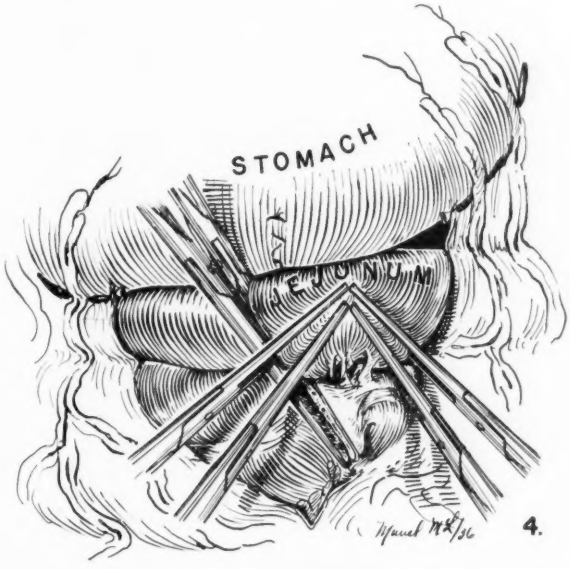

Fig. 4.—Note the hypertrophy of the jejunum usually found in such cases. In this instance, it was possible to remove a wedge-shaped piece of the jejunum between clamps with the actual cautery instead of a complete transverse section as is necessary in some instances. The defect in the jejunum was closed in the same manner as described in Fig. 3.

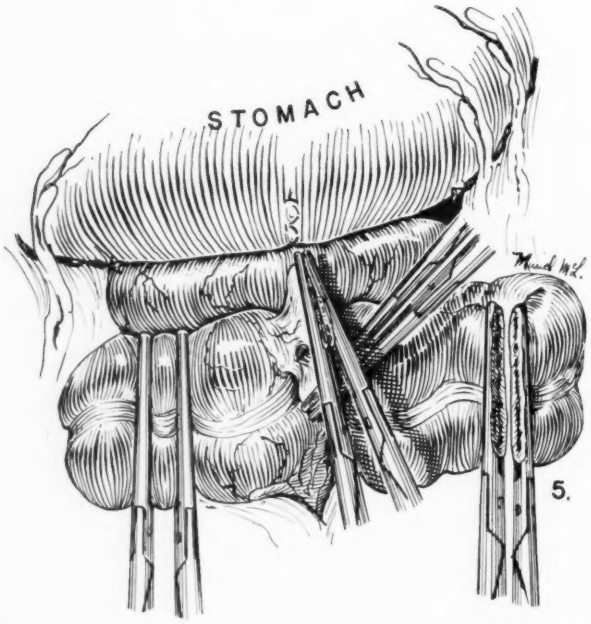

Fig. 5.—Section of the transverse colon now completely freed of blood supply, and its attachment to the jejunum and stomach is burned out between clamps.

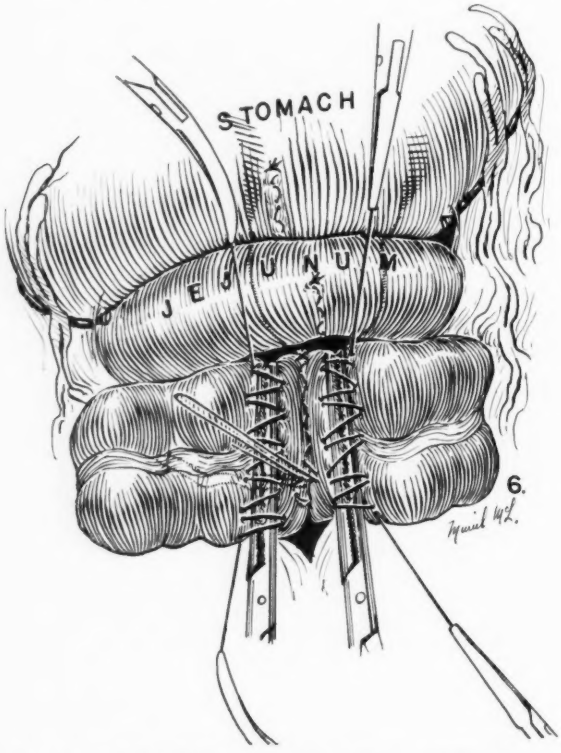

Fig. 6.—First and second steps in the modified Kerr anastomosis in the transverse colon. Note that the basting stitch later to be withdrawn is marked on one side with curved hemostats and on the other side with straight forceps for purposes of identification later. Also, note that the first posterior row of stitches is placed before the clamps are withdrawn. This keeps the bowel ends in approximation while the remaining layers of sutures are placed.

lesions. No radical attempt was made to relieve the remaining two. One was in a severe state of malnutrition, with deficiency disease in its most advanced form already present on entering the hospital. He refused treatment, went home against advice, and died twenty-one days later. The remaining patient in this group was seventy-two years of age; he had had two previous operations on his stomach and improved somewhat on a careful dietary regime.

Every surgeon who has to deal with these lesions is grateful for any suggestions that make the operative procedure simpler and safer.

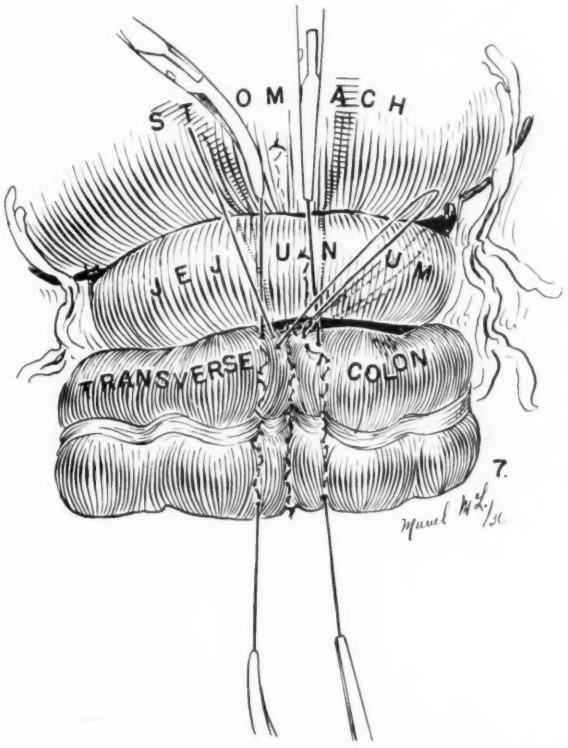

Fig. 7.—The clamps have been withdrawn and the basting stitches brought up tightly, temporarily closing in the cut ends of the bowel. A second posterior row of stitches is now applied.

Based on the experiments of Mann and Williamson[3] demonstrating that chronic ulcers can be produced by exposing duodenal mucosa to the gastric secretions unmodified by the normal duodenal contents, and further that these experimental ulcers heal if the normal relationships are restored, Schrimger[4] recently has called attention to some basic factors in dealing with gastrojejunal ulcers and gastrojejunocolic fistulas. He has added his own observations that the gastrointestinal tract will heal by approximation of the muscularis if the mucosa is previously removed. Schrimger advocates leaving the

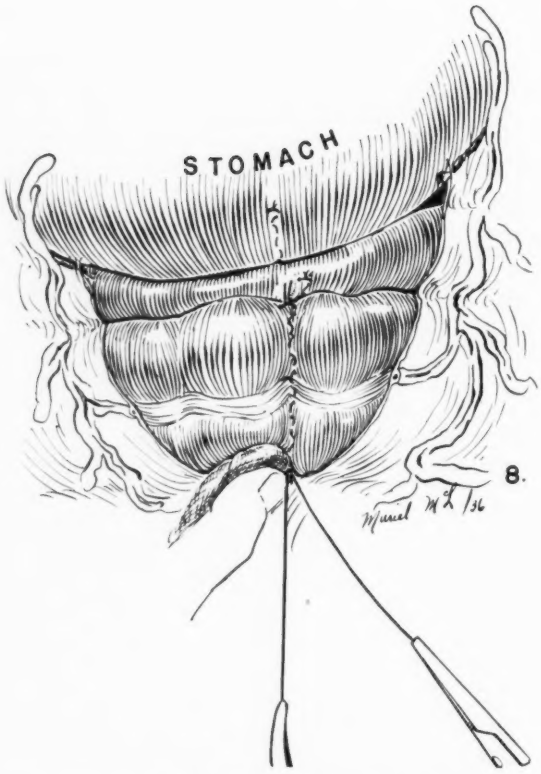

Fig. 8.—The first row of sutures anteriorly has been applied over the basting stitch. The basting stitches have been cut at the upper border and are ready to be withdrawn.

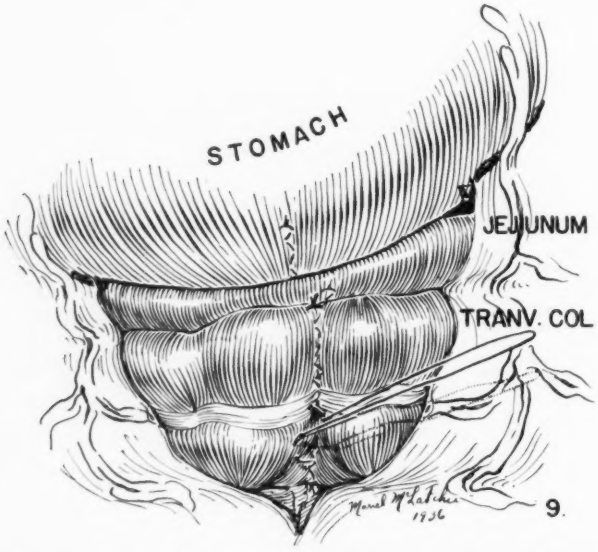

Fig. 9.—The second row of sutures is applied anteriorly. This method approximates a fairly wide serosal surface at the anastomosis. This, we believe, should be approximately 5 mm. in width.

jejunal ulcerations even if the colon has been penetrated, resecting three-quarters of the stomach with the exception of a portion one and one-half inches wide around the old stoma. From this remaining area, the mucosa is removed, and the muscularis and peritoneal coat sutured by everting the edges as in arterial suture. This simplifies the closure of these thickened structures and has in five instances resulted in firm healing. There was an unfortunate late death in the one case of gastrojejunocolic fistula of the series from a leak in his anterior Polya anastomosis. The method resulted in excellent recovery in the four patients with uncomplicated jejunal ulcers. Estes[5] in his discussion of Schrimger's paper before the American Surgical Association in

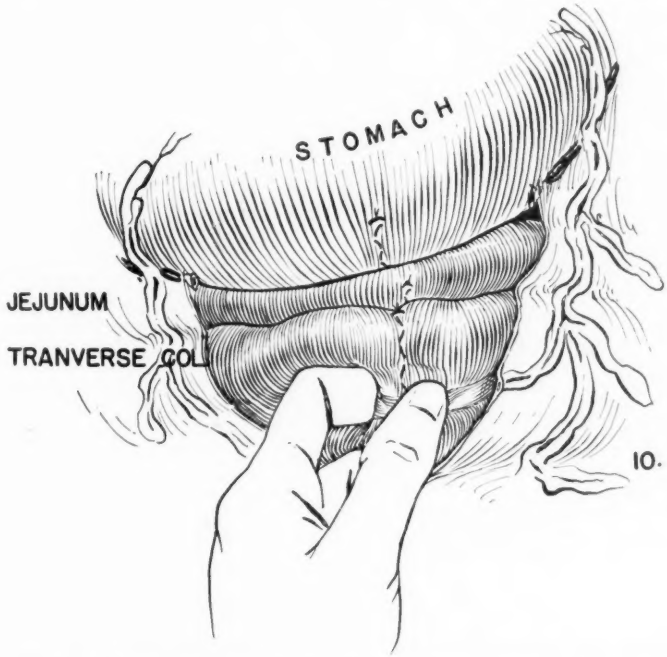

Fig. 10.—A most important step in the Kerr aseptic technic. The cautery-seared surfaces have a tendency to remain glued together after the basting stitch has been withdrawn. One must be absolutely certain that this seal is definitely broken by invagination over the thumb and finger. The operation is finished by a careful approximation of the gastrocolic omentum over the suture lines.

1935 called attention to a somewhat similar technic which he had reported before the Johns Hopkins Surgical Society four years before. He had inverted a cuff of stomach about a gastrojejunal ulcer and made a lateral anastomosis around the lesion in the jejunum. Much to his delight, when the patient was reoperated upon a few weeks later for a reactivated duodenal ulcer, he found the old jejunal ulceration completely healed, and the jejunum in this region atrophied.

Presented with the problem of a gastrojejunocolic fistula recently, it was decided to take into consideration the possibilities brought

forth in Schrimger's paper and Estes' discussion, combining if possible, some modification that would eliminate contamination of the peritoneal cavity, since in dealing with this lesion we must face the fact that the stomach and jejunum will contain the same bacteria as the colon itself; this was brought forcibly to mind by the fact that two out of eight patients operated upon by the open method in our hospital had succumbed to peritonitis. Theorizing about the possibilities prior to the operation, we decided that in order to eliminate the septic factor, we were probably committed to a two-stage procedure. Could we use the ideas of Estes and Schrimger and aseptically separate a wedge of stomach around the stoma between clamps with the cautery, close the cuff and the opening in the stomach, and leave the resection and Polya anastomosis for a future operation? Would it

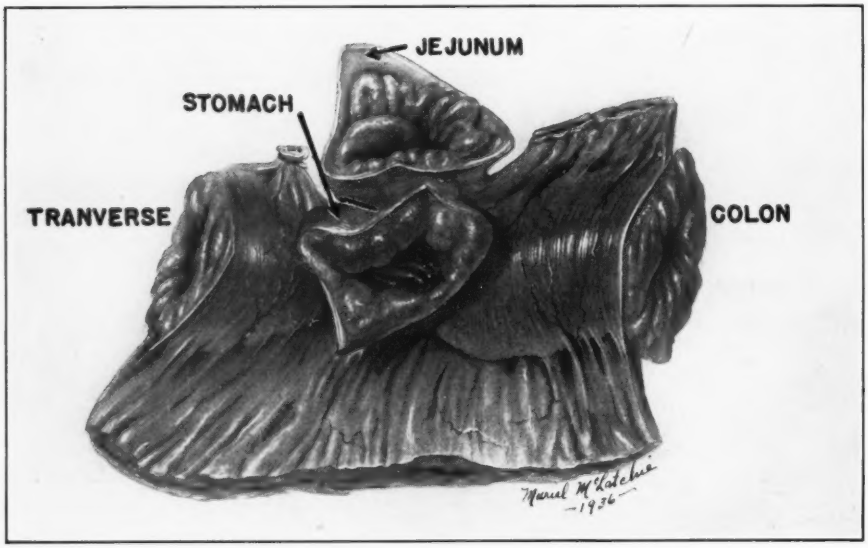

Fig. 11.—Photograph of a specimen of gastrojejunocolic fistula removed by aseptic technic. (See Case Report.)

be feasible to transect the transverse colon on either side of the fistula, do an end-to-end union and leave behind the segment of colon to which the stoma was attached? This last possibility might be considered seriously when dealing with an extremely large ulceration into the colon. Wilkie[6] used this idea in dealing with a gastrojejunocolic fistula that had developed spontaneously in a posterior wall gastric ulcer. We might dare attempt both steps, leaving the stomach closed and the colon reanastomosed, depending on the opening from the colon into the jejunum to take care of the infection in the remaining segment of colon. If the endurance of the surgeon and the patient were adequate, one might carry on this idea of aseptic resection to include half or two-thirds of the stomach and join the remaining portion of

the stomach by an aseptic Billroth II, although it is my opinion that Kerr's technic as applied to gastrojejunostomy is less adaptable than it is when used in the bowel alone. This fear is based primarily on the possibility of inadequate control of hemorrhage on the thick stomach wall.

CASE REPORT.—No. 350824: A thirty-year-old, married laborer entered the medical wards of the hospital on January 10, 1936, complaining of diarrhea, weight loss, and abnormal appetite for two years. He had been operated upon in another hospital six years before for a perforated duodenal ulcer. A posterior gastroenterostomy had been done at the time of the suture of the perforation. He had been well until two years ago, when he suddenly developed diarrhea eighteen times a day. He lost forty-three pounds in weight in spite of eating three times as much as a normal individual and drinking fifteen glasses of water daily. Aside from duodenal ulcer symptoms starting seven years ago, his past history is irrelevant. His family history is not contributory. Physical examination on entry showed an emaciated man, with a fecal odor to his breath, in no distress. The teeth were poor. Bubbling râles were heard throughout the chest; there was some cough from recent infection. A blowing systolic murmur was heard at the apex. The blood pressure was 107/60. The abdomen was distended and full and tympanic throughout. There was a sense of resistance under the epigastric scar. Very loud peristalsis could be heard. X-ray examination showed considerable gastritis and a posterior gastroenterostomy with small stoma, some of the barium passing directly into the transverse colon. This was confirmed by barium enema. Definite diagnosis of gastrojejunocolic fistula was made.

Laboratory studies revealed a serum protein of 4.5 per cent. Gastric analysis showed a normal amount of free and total acid. His leucocyte count was around 17,000 on four successive days; hemoglobin, 70 per cent; red cells, 4,500,000. The stools were filled with undigested food particles.

Patient improved somewhat while in the ward and gained some weight. Inasmuch as his upper respiratory tract infection was slow in clearing, he was discharged home on February 8, 1936, four weeks after entry, to return later for operation.

Second admission to the surgical wards on June 6, 1936. The patient had found that by remaining quiet at home he could maintain the gain which he had made in the hospital. Any activity, however, increased his diarrhea and caused weight loss. On this admission his serum protein was 3.6 per cent. He was given a blood transfusion and subjected to operation on June 12, 1936. The operative procedure carried out was an aseptic resection of the gastrojejunocolic fistula with closure of the three structures involved as depicted in Figs. 1-10. He has remained well for four months on a six-meal bland diet. He is able to work. He is being followed in the Gastrointestinal Clinic and will be readmitted if the original ulcer in the duodenum becomes reactivated.

SUMMARY AND CONCLUSIONS

1. The importance of approximate aseptic handling of structures infected with colon and intestinal contents is stressed.

2. A method applicable to one case of gastrojejunocolic fistula is related in detail.

3. The incidence of gastrojejunocolic fistula developing on postoperative gastrojejunal ulcer in our hospital is approximately 14 per cent.

4. The mortality in this small group of ten cases was 30 per cent.

5. The mortality for radical operation to relieve this situation in this series was 25 per cent.

6. Selected cases may be treated by conservative measures.

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SPONTANEOUS INTERNAL BILIARY FISTULA AND GALLSTONE OBSTRUCTION

With Particular Reference to the Roentgenologic Diagnosis*

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THE incidence of spontaneous internal biliary fistula in operative and autopsy records is very low, but it is probable that the actual frequency is greater than such statistics would indicate. Some idea of this reported incidence may be obtained in Table I. Although less than 10 cases, in which the diagnosis had been made by roentgen examination, were reported prior to 1928, since that time over 50 cases of true fistula, not including postoperative cases, have appeared in the roentgenologic literature. The ability to recognize, by means of x-ray examination alone, both a true internal fistulous connection between the biliary system and the gastrointestinal tract and a fistulous dilatation of the common bile duct has resulted in a rapid accumulation of recorded instances. As time goes on, this method of diagnosis will no doubt change our previous concept of the rarity of this condition.

Table I

Incidence of Spontaneous Internal Biliary Fistula

Authors	No. cases examined	Positive findings	Per cent
Roth, Schroeder and Schloth	10,866 (autopsies)	43	0.39
University of Minnesota Hospital	19,474 (autopsies)	24	0.12
Kehr	2,000 (cholecystectomies)	100	5.0

The importance of the demonstration of a spontaneous internal biliary fistula, both with regard to the lesion itself and as a finding indicative of gallstone obstruction, cannot be exaggerated. The diagnosis of this condition can be accurately made by roentgen examination alone in such a high percentage of cases that some emphasis on the roentgen findings seems advisable.

PATHOLOGY

Anatomically, the path taken by a biliary fistula is by no means limited. Gallstones have been vomited from the stomach, coughed up from the bronchial tree, voided in the urine, and frequently passed

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per rectum. Fistulous tracts have been found between the gallbladder and the stomach, duodenum, jejunum, ileum, colon, and appendix; between the gallbladder, the common and hepatic ducts, and the liver. They have been traced to the pelvis of the kidney, the urachus, the urinary bladder, and the sex organs. Extreme rarities are connections with the pericardial cavity, the pregnant uterus, and an ovarian cyst. The most frequent tract is between the gallbladder and the first and second portions of the duodenum. In the majority of cholecystoduodenal fistulas the gallbladder is connected directly to the proximal part of the second portion of the duodenum. The occurrence of a fistula between the bile ducts and the duodenum (choledochoduodenal), according to the collected autopsy cases, forms only a small percentage of the group. Moynihan[76] has stated, however, that the choledochoduodenal type probably occurs with greater frequency than

TABLE II

CLASSIFICATION OF TYPES OF INTERNAL BILIARY FISTULA BASED ON AUTOPSY STATISTICS, AND COMPARISON WITH TYPES DIAGNOSED BY ROENTGEN EXAMINATION

	NAUNYN[78]	PER CENT	ROTH, SCHROEDER AND SCHLOTH	PER CENT	UNIV. OF MINN. AUTOPSIES	PER CENT	ROENTGENOLOGICALLY DIAGNOSED CASES*	PER CENT
Total number cases	200		43		24		83	
Cholecystoduodenal	93	46.5	19	44.0	17	70.0	31	37.0
Choledochoduodenal	15	7.5	5	11.0	1	4.0	16	19.2
Cholecystocolic	49	24.5	16	37.0	6	25.0	10	14.4
Cholecystogastric	8	4.0	1	2.3			3	3.6
Regurgitation through common duct							16	19.2

The discrepancy between the total number of cases reported by each author and the total of the classified cases under his name is due to inclusion of only five types of fistulas in the classification.

*Does not include herein reported cases.

has been thought. This is borne out by cases reported in the roentgen literature in which this type of fistula forms a much greater percentage of the total than the autopsy statistics would indicate. The classification of the previously reported groups of autopsy cases is shown in Table II, which includes also a classification of the types of cases found in our own autopsy series.

Internal biliary fistulas are most frequently caused by gallstones. Perforating duodenal ulcers constitute the second most important cause, while neoplastic growths are only an occasional etiologic factor. Only 23 of the 153 cases reported by Judd[51] showed no evidence of stones. In 23 of the 24 cases found by us in the autopsy records of the Department of Pathology of the University of Minnesota, there was an

associated cholecystitis and cholelithiasis. In 14 of 16 cases of the choledochoduodenal type reported in the roentgenologic literature, a diagnosis of duodenal ulcer was indicated either by the clinical history or by the operative findings. Neoplastic growths have been said to be associated with the cholecystocolic type of fistula more than in any of the other types. Murcheson,[77] for example, found carcinoma as the cause in 6 out of 9 cases. Most of the cases recognized on x-ray examination, however, have been due to gallstones. In our autopsy records only one of 6 cases was associated with a carcinoma.

Common duct obstruction, usually by a stone, with a patent cystic duct, is an important associated pathologic condition. The biliary obstruction thus produced is the initial factor in the fistula formation. Even though a stone is not found in the common duct at operation, evidence of previous obstruction is nearly always present. The intimate anatomic relationship between a distended gallbladder and the second part of the duodenum accounts, no doubt, for the greater frequency of fistulas between these two organs. Similarly the proximity of the common duct to the first portion of the duodenum, as it courses in the hepatoduodenal ligament, may account for the association of duodenal ulcer with fistulas into the common duct.

There is general agreement as to the usual pathologic process concerned in the formation of a fistula, and this has been sufficiently discussed in previous papers[75, 102] so that it need not be repeated here. Attention, however, should be called to the fact that a regurgitation from the intestinal tract through the fistula into the biliary system may occur and, consequently, intestinal contents can be demonstrated in the bile ducts. Gas under definite pressure has been found in a number of cases in which the common duct has been explored at operation. This accounts, no doubt, for the roentgenologic findings which will be described later.

A fistulous tract once formed may close spontaneously upon removal of the obstructing factor. The only resulting evidence of the fistula, then remaining, is visceral adhesions between the organs involved. It is probably for this reason that biliary fistulas are so rarely found at the autopsy table. Courvoisier's[22] statement that there are three times as many cases of intestinal obstruction due to gallstones, reported in the literature, as there are cases of gallbladder-intestinal fistula, emphasized the fact that internal biliary fistula must be a much more frequent occurrence than postmortem statistics would indicate. In all these cases of gallstone obstruction a fistulous opening must have been formed or the common duct dilated to a fistulous character, but the disappearance of the fistula prevents its detection, either at operation or at autopsy.

In the majority of instances gallstones probably enter the intestinal tract through the common duct rather than by true fistula formation.

The ability of the common duct to pass stones large enough to produce intestinal obstruction is amazing, but verified reports of such cases have been recorded. From the roentgenologic standpoint such a passage produces a condition which is quite similar to a true internal biliary fistula. Dilatation of the terminal portion of the common duct by a passing stone often results in a temporary or permanent loss of the sphincteric function formerly present in the distal end of the duct, and in the duodenal wall. Williams and Bush[118] have cited anatomic and experimental evidence to prove that an incompetent sphincter of Oddi is most commonly caused by the passage through it of a large stone. Åkerlund,[1] however, has shown that chronic pancreatitis may also be related to an incompetent sphincter; temporary incompetence likewise occurs following cholecystectomy. As in the case of a true fistula, regurgitation can be brought about by increasing the duodenal pressure, below the sphincter of Oddi, above that of the biliary pressure in the common duct. Clinically also the condition may resemble, in certain respects, a true internal fistula. In consideration of the frequency of common duct stones and their passage into the intestinal tract, it is logical to suspect that a loss of this sphincteric action is frequently found. Courvoisier,[22] in studying a series of cases of common duct stones, found that 14 per cent had a dilated and wide open ampulla of Vater. Since an incompetent sphincteric action is difficult to demonstrate at the postmortem table, it follows that this condition may be diagnosed by x-ray examination far more frequently than autopsy statistics would indicate. It will be noted in Table II that practically 20 per cent of the cases diagnosed by roentgen examination show this type of fistulous formation. For practical purposes, this mode of communication between the biliary tree and the intestines may be considered fistulous even though the tract is through a natural duct.

CLINICAL FINDINGS

Sudden and unusual relief from long-standing intermittent gallbladder pain and jaundice constitute the chief clinical features of spontaneous internal biliary fistula. Nevertheless, cases have been reported with absence of any symptoms referable to this condition. Despite the reflux of gastrointestinal contents into the biliary system, clinical cholangeitis is not a frequent finding. The absence of evidence of infection, however, does not preclude the possibility of pathologic changes occurring in the biliary tract and liver, as has been pointed out by Beaver.[7] Diarrhea, cramps, and emaciation are frequently associated with the cholecystocolic type of fistula, while symptoms suggesting intestinal obstruction in varying degrees are present in about one-half of all types of cases. Some degree of chronic cholecystitis is practically always present in all cases, and an active fistula will usually perpetuate the symptoms which have been present. A

relative absence of symptoms, in the presence of an active fistula, is, no doubt, explained by the wide open stoma and the free drainage of the biliary system which this permits. A well-healed fistula may produce no definite symptoms whatever.

ROENTGENOLOGIC DIAGNOSIS

Previous to the era of roentgen diagnosis the preoperative or ante mortem diagnosis of internal biliary fistula was seldom if ever made. Emesis of a gallstone or its passage per rectum constituted practically the sole diagnostic sign. At the present time certain roentgenologic criteria indicate the presence of internal fistula with almost positive certainty, and these can be obtained with relative ease.

In 1915, Hunt and Herbst[47] reported a case in which the barium meal study showed an apparent duodenal diverticulum. At operation, subsequently, a cholecystoduodenal fistula was found. Case,[21] in 1916, reported the x-ray findings in two cases of postoperative cholecystoenterostomies. A year later Carman and Miller[20] observed filling of the biliary tree with barium and at operation a cholecystoduodenal fistula was present. In 1919, Busi[17] observed both gas and barium in the bile ducts, assumed a fistulous connection with the intestinal tract to be the cause, and the diagnosis was substantiated at operation. Judd and Burden,[51] in 1925, reported 153 cases of spontaneous internal biliary fistula, only one of which had been diagnosed by x-ray examination. In 24 cases found in the autopsy records of the Department of Pathology of the University of Minnesota from 1925 to 1935, only one case had been diagnosed by this means. Since 1928, however, numerous reports have appeared, there being at this time 78 recorded cases in the literature, if the cases of dilated common duct be included. To these we wish to add 8 cases of our own. The cases previously reported as diagnosed by roentgen examination are listed in Table III and the classification as to types is indicated. In this table are also included the cases artificially produced by surgical procedures which have been demonstrated by x-ray examination. The cases, roentgenologically diagnosed, which we are reporting, are summarized in Table IV.

The roentgenologic signs of internal biliary fistula may be summarized briefly as follows:

1. Direct Signs
   a. Gas, or barium, or both in the gallbladder or biliary tree.
   b. Mucous membrane changes at the stoma of the fistula.
2. Indirect Signs
   a. Nonfunctioning gallbladder (cholecystogram).

The most important x-ray sign of an internal biliary fistula is the presence of gas in the gallbladder or bile ducts. It must be borne in mind, however, that this may occur as a result of three conditions.

TABLE III

TYPES OF SPONTANEOUS INTERNAL BILIARY FISTULA REPORTED DIAGNOSED BY ROENTGEN EXAMINATION

AUTHOR	NUMBER OF CASES	YEAR
1. *Cholecystoduodenal*		
Hunt-Herbst	1	1915
Carman-Miller	1	1917
Shoup	1	1917
Busi	2	1921
Havlicek	1	1925
Tandoia	1	1925
Habbe-Smith	1	1926
Haenisch	1	1926
Gavazzeni-Lusso	1	1928
Friedrich	1	1929
Harding	1	1929
Martinotti	1	1929
Öhnell-Lindbloom	1	1929
Dalsace	1	1930
Buisson	1	1931
Crane	1	1931
Delhern	1	1931
Gråberger	1	1931
Jenkinson-Brouse	1	1931
Lenarduzzi	1	1931
Lust	1	1931
Beutel	1	1932
Cristofanetti	1	1932
Frugoni	1	1933
Sickels-Hudson	1	1934
Paul	2	1934
Blefari-Melazzi	1	1934
Kaiser	1	1934
Schéle	1	1935
Total	31	
2. *Regurgitation Into Common Duct*		
Stephenson	1	1921
Beall-Jagoda	1	1921
McArthur	1	1923
Fishbaugh	1	1926
Sighinolfi	1	1926
Venables-Briggs	2	1929
Davis	2	1929
Johannesson	2	1929
Reiman	1	1930
Jenkinson-Brouse	1	1931
Nemours Auguste-Jahiel	1	1932
Rees	1	1933
Engels	1	1934
Total	16	
3. *Choledochoduodenal*		
Berg	1	1926
Alberti	1	1927
Kantor-Jaffin	2	1928
Fraticelli	1	1931
Kern	1	1931
Meldolesi	1	1931
Lewin	1	1932
Lönnerblad	1	1932
Arntzen	1	1932
Mardersteig	1	1932
Lamarque	1	1933
Bignami-Agati	4	1934
Total	16	

AUTHOR	NUMBER OF CASES	YEAR
4. *Cholecystocolic*		
Judd-Burden	1	1925
Reich	1	1929
Schinz	1	1932
Lönnerblad	1	1932
Prévôt	1	1933
Vorhaus-Rogers	1	1934
Podlasky	1	1934
Blefari-Melazzi	1	1934
Candel-Wolfson	1	1935
Medelman	1	1936
Total	10	
5. *Cholecystogastric*		
Smith	1	1928
Rankin	1	1932
Pohlandt	1	1934
Total	3	
6. *Cholecystoduodenocolic*		
Fuller	1	1931
7. *Cholecystojejunal*		
Fraticelli	1	1931
8. *Choledochocolic*		
Meese	1	1935
9. *Biliary-Bronchial*		
Kopáry	1	1928
Cannavo-Cola	1	1931
Laird-Wilkerson	1	1932
Razemon	1	1933
Total	4	
10. *Types of Artificial (Postoperative) Biliary Fistula Demonstrated by Roentgen Examination*		
Cholecystoduodenostomy		
Case	2	1916
Hoseman	3	1923
Prevot	1	1923
Lenk	1	1925
Odischaria	1	1929
Friedrich	1	1929
Parade	1	1930
Gråberger	2	1931
Schinz	1	1932
Sickels-Hudson	1	1934
Total	14	
Cholecystogastrostomy		
Ralphs	1	1922
Gulecke	1	1923
Mallet-Guy-Beaupere	4	1926
Hutter	2	1927
Von Orth	1	1928
O'Bannon	1	1928
Rybak	1	1931
Béclère	2	1934
Total	13	
Choledochoduodenostomy		
Swalm-Manges	1	1929
Fetzer	1	1930
Westphal	1	1930
Walters-Thiessen	1	1934
Total	4	

1. Spontaneous or operative fistulous connection between some part of the biliary system and the gastrointestinal tract.

2. Regurgitation through the sphincter of Oddi via the ampulla of Vater.

3. Emphysema from bacterial action.

The presence of gas in the biliary ducts (Figs. 1, 4, and 7) may be detected by linear areas of rarefaction, tubular in shape, and with the characteristic branching of the bile ducts. In some respects gas may be detected more easily than barium, as it may be shown in the ordinary films of the gallbladder region without the use of any contrast media. While the vascular markings of the liver may rarely simulate a gas-filled biliary tree, the shape of the bile ducts is usually so characteristic that they are unmistakable. The visualization of the gas-containing biliary system gives less specific information than does the presence of barium as to the type of pathology present, in that no localization of the fistula may thus be obtained. The presence of gas, however, is definite evidence of either a fistula, an incompetent sphincter, or emphysema from bacterial action—a very rare occurrence. We have seen one case of the latter type, and here the bubblelike character of the gas shadows permitted a ready differentiation. It is notable that gas may be detected in the gallbladder films of cases in which efforts to produce a barium filling of the biliary system have failed. It is advisable to make the examination in both the anteroposterior and posteroanterior positions, as the gas will occasionally be observed in one when not seen in the other. The presence of gas is no doubt the most reliable single sign of a pathologic connection between the biliary system and the intestinal tract.

The second finding is a right paraduodenal accumulation of the contrast media which represents a filling of the gallbladder itself (Figs. 2, 7, and 9). The gallbladder alone or, in addition, the cystic and hepatic ducts, may be demonstrated. Extensive filling of the biliary tree is unusual; more often only the lowermost portion will be seen. Certain procedures greatly facilitate the filling of the biliary system with contrast media. An examination in the prone position with the patient lying on his right side is most likely to produce a filling, following a wave of peristalsis in the duodenum. Reexamination half an hour after the ingestion of the barium meal, during which time the patient has been recumbent and turned on his right side, will also often be effective. The pocket of contrast media seen in these cases must be differentiated chiefly from a duodenal diverticulum. Usually diverticula occur on the mesenteric side of the duodenum rather than on the lateral side, as is the case with barium in the gallbladder. Furthermore, the latter shadow is often irregular, segmented, or stippled

TABLE IV

CASES HEREIN REPORTED OF SPONTANEOUS BILIARY FISTULA ROENTGENOLOGICALLY DIAGNOSED

CASE	CHIEF COMPLAINT ON ADMISSION	CLINICAL DIAGNOSIS	FIRST ROENTGEN SIGN NOTED	FINAL ROENTGEN DIAGNOSIS	SURGICAL OR AUTOPSY FINDINGS
1	1. Epigastric pain 2. Vomiting 3. Chills 4. Fever	Chronic cholecystitis	Gas in bile ducts	Choledochoduodenal fistula: extension of barium from duodenum directly into upper portion of common duct	
2	1. Abdominal pain (colic) 2. Weight loss 48 pounds in two years 3. Food distress 4. Gallbladder attacks for years	Chronic cholecystitis	Gas in bile ducts	Regurgitation through incompetent common duct sphincter	
3	1. Unusually severe attack of right upper quadrant pain with food distress but without previously noted jaundice 2. Relief of pain in short time, but with onset of persistent vomiting 3. Gallbladder attacks for 31 years	Intestinal obstruction	Barium in gallbladder fossa	Cholecystoduodenal fistula with obstruction due to gallstones: (1) Barium and gas in gallbladder, bile ducts and fistula. (2) Mass of stones in lower left quadrant. (3) Absence of previously noted stones in gallbladder	*Postmortem:* cholecystoduodenal fistula with gallstone obstruction
4	1. Vague abdominal distress for several days 2. Sudden severe crampy, colicky abdominal pain, with vomiting	(1) Paralytic ileus (ruptured appendix). (2) Mesenteric thrombosis. (3) Obstruction due to gallstones	Gas in bile ducts	Biliary intestinal fistula with obstruction due to gallstones (exact type indeterminate)	*Surgical:* obstruction due to gallstones. *Postmortem:* cholecystoduodenal fistula

TABLE IV—CONT'D

CASE	CHIEF COMPLAINT ON ADMISSION	CLINICAL DIAGNOSIS	FIRST ROENTGEN SIGN NOTED	FINAL ROENTGEN DIAGNOSIS	SURGICAL OR AUTOPSY FINDINGS
5	1. "Foamy" diarrhea, 2 yr. 2. Weight loss 100 pounds 3. Gastric distress one-half hour after eating	Carcinoma of pancreas or bile ducts	Gas in bile ducts	Biliary-intestinal fistula (exact type indeterminate)	
6	1. Gastric distress 2. Weight loss 30 pounds in two months 3. Five-year history of gallbladder attacks	Chronic cholecystitis	Barium filling of common duct	Regurgitation through incompetent common duct sphincter: (1) regurgitation through common duct into hepatic ducts. (2) Mucous membrane changes at ampulla	
7	1. Epigastric pain 2. Vomiting	(1) Perforated peptic ulcer. (2) Acute pancreatitis	Gas in bile ducts	Spontaneous biliary fistula, cholecystoduodenal type: (1) Barium in fistula extending to gallbladder. (2) Gas in bile ducts. (3) Mucous membrane changes	*Surgical:* cholecystoduodenal fistula
8	1. History of gastric distress after eating over a period of forty years 2. Particularly severe attack five months ago, with persistence of pain	Chronic cholecystitis	Extension of barium from duodenum into region of gallbladder	Probable cholecystoduodenal fistula: (1) Direct extension of barium into irregular area, probably gallbladder. (2) Filling of bile ducts with barium	*Surgical:* cholecystoduodenal fistula

in appearance, while diverticula are smooth and rounded. In addition, folds of mucous membrane may frequently be demonstrated in the neck of a diverticulum, whereas these are obviously absent in the tract of a fistula or even in a dilated common duct.

Changes in the contour of the mucous membrane of the gastrointestinal tract around the stoma of the fistula are regularly present (Figs. 2 and 5). The folds of mucous membrane are irregular and indistinct and show a loss of elasticity. These findings often simulate the mucous membrane change seen in carcinoma. The duodenal bulb, when it is the site of the fistula, shows a constant irregular defect in its contour (Fig. 2), probably secondary to these mucous membrane changes. Partial stenosis of the duodenum may also be present, particularly in the second portion just beyond the duodenal bulb. In the cholecystocolic type of fistula, irregular spastic contraction at the site of the stoma in the colon can usually be made out.

Cholecystographic study, with rare exceptions, shows a nonfunctioning gallbladder. Since cholecystitis is almost always present due either to the original inflammatory condition or to persistence of the infection from regurgitation, the above finding is a most frequent accompaniment of biliary fistula. Negative cholecystograms, therefore, constitute strong evidence against the presence of any fistulous connection.

The various types of fistula have somewhat different characteristics. In general, the distinction is largely based upon the position of the barium-filled fistula in relationship to the gastrointestinal tract and the location of the mucous membrane changes previously described. In the cholecystoduodenal fistula, for example, the usual findings are a right paraduodenal accumulation of barium (Figs. 7 and 9), visualization of a fistulous tract and of the cystic and hepatic ducts filled with air or barium (Fig. 7), a deformed bulb or local mucous membrane changes in the upper portion of the second part of the duodenum, and evidences of a nonfunctioning gallbladder. The findings in this type of fistula are illustrated in the report of Case 3. This case showed, in addition, a gallstone obstruction.

In the choledochoduodenal fistula, there is shown first, a filling of the upper portion of the common duct with barium which extends directly from the duodenum. This is followed by filling of the cystic and hepatic ducts and possibly the gallbladder itself. The following case is reported to illustrate the findings in this type of fistula.

CASE 1.—A woman, aged fifty-four years, was first seen April 26, 1934. She stated that for the past six years she had had recurrent attacks of epigastric pain, vomiting, chills, and fever. During the first attack in 1928, the patient was jaundiced; in the subsequent attacks no jaundice was noted. A cholecystogram on

May 2, 1934, showed a pathologic nonfunctioning gallbladder, and gas could be visualized in the bile ducts (Fig. 1). A gastrointestinal examination on May 7, 1934, showed a deformed duodenal bulb and extension of barium from the duodenum directly into the common duct (Fig. 2). The upper portion of the dilated common duct, and very probably the distal end of the adjoining cystic duct, both filled with barium, could be visualized just above the duodenal bulb. The lower portion of the common duct was not visualized. Roentgen diagnosis: Choledochoduodenal fistula.

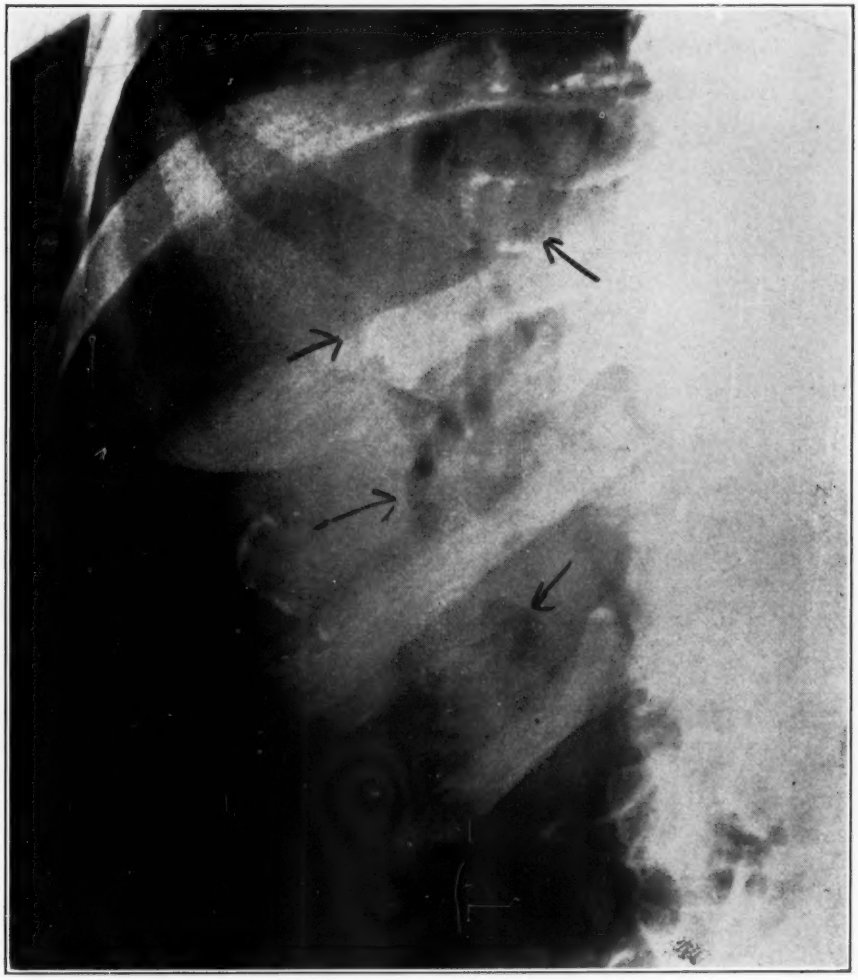

Fig. 1.—Case 1. Typical roentgenogram of gallbladder region, showing gas-filled biliary ducts (arrows). Lower arrow points to upper portion of common duct. Note the tubular shape and branching course of the areas of increased radiability representing the smaller ducts.

COMMENT

Gas in the biliary tree indicated a fistula, and the tract between the common bile duct and the duodenum was determined by the barium meal examination. Filling of the upper portion of the common duct, with absence of barium in the lower half is the crucial point in deter-

mining the exact type of fistula. The duodenal irregularity and absence of a shadow of the gallbladder itself are also important points.

The initial attack experienced by the patient was probably associated with biliary obstruction, since the patient was jaundiced. The subsequent absence of jaundice indicates relief of the biliary obstruction. The recurrent chills, fever, vomiting, and pain might well be associated with cholangitis.

The fistula formation probably accounted for the entire picture, since it provided a biliary drainage, yet permitted regurgitation of intestinal contents into the ducts, with the subsequent development

Fig. 2.—Case 1. Roentgenogram after barium meal. Note the barium extending into the dilated, irregular common duct (medial arrow). The cystic duct with barium filling is shown to the right, and the gas-filled hepatic ducts are shown above (arrows). Note the deformity of the duodenal bulb into which the fistula extends. Mucous membrane changes are also present (lateral arrow).

of cholangitis. If regurgitation occurs over a period of years, pathologic changes in the biliary system are a very likely consequence.

When a choledochoduodenal fistula communicates with the duodenum beyond the bulb, it can only rarely be differentiated, by roentgen examination alone, from regurgitation through a wide ampulla and a dilated common duct. In the latter case, the characteristic finding is barium filling the common duct (Fig. 5) at its normal site, beginning medially in the midportion of the second part of the duodenum, about ten centimeters from the pylorus. In the case of a true fistula, in

which there is a communication with the proximal segment of the common duct, this fills directly after the filling of the first portion of the duodenum, and the diagnosis may be readily apparent. When a true fistula, however, has its entrance near the ampulla of Vater, the difficulty of differentiation from other conditions becomes very great. Aside from the possibility of a dilated ampulla producing this finding, there is also the possibility of a true duodenal diverticulum, which may also produce a pocket of barium in this region. Diverticula are very frequently found near the ampulla of Vater, and in an occasional case it may be impossible to differentiate them. Visualization of the common and pancreatic ducts together, in a fork-shaped manner, with rapid emptying after filling, may be observed, if there is a dilated ampulla of Vater. Diverticula are characteristically round and smooth, without any such forking of the neck; usually there is retention of barium for a considerable period of time. The following case is reported to illustrate the roentgen diagnosis of a dilated common duct with regurgitation.

CASE 2.—A woman, aged sixty-seven years, was admitted to the University Hospital on Sept. 28, 1928. The history obtained was typical of chronic gallbladder disease. Subsequent cholecystographic studies showed a large gallstone in the gallbladder (Fig. 3). For various reasons no gallbladder surgery was undertaken at that time. The patient revisited the outpatient clinic with practically the same type of complaints on Feb. 19 and March 26, 1929. She was readmitted on May 13, 1929, at which time the patient reported the passage per rectum of a large gallstone. Previous to passage of the stone the patient had experienced crampy, colicky abdominal pains. She had also noted fatty food distress, and occasionally constipation. After the passage of the stone there was considerable improvement in her condition.

A cholecystogram on Aug. 1, 1929, showed gas in the bile ducts and the previously reported gallstone was not visualized (Fig. 4). Gastrointestinal examination with a barium meal showed regurgitation of the media into the common bile duct (Fig. 5). This formed the basis for the diagnosis of incompetency of the common duct sphincter from passage of a large gallstone.

COMMENT

Gas in the biliary tree indicated the presence of a fistulous connection between the biliary tract and the intestinal tract. The disappearance of the previously demonstrated calculus confirmed this. The exact type of fistula, namely an incompetent common duct sphincter, was demonstrated by barium filling of the common duct. The length of time the common duct sphincter remains incompetent following passage of a stone is indefinite. In this case the sphincter had remained incompetent for at least two and a half months.

Despite the regurgitation of intestinal content into the bile ducts, which undoubtedly occurred, the symptoms were not indicative of cholangitis. This demonstrates the fact that clinical cholangitis does

not invariably result when regurgitation of intestinal contents into the biliary system occurs. Following passage of the stone per rectum, this patient improved quite markedly. She refused operation on the grounds that her general health had improved. If regurgitation continues over a period of years, pathologic changes in the biliary system are practically certain to take place. It then becomes apparent that the cure by fistula formation may be worse than the disease itself.

Fig. 3.—Case 2. Cholecystogram made Oct. 9, 1928, showing a single large gallstone (arrows).

In the cholecystocolic type, the fistula practically always joins the colon at the right hepatic flexure. Cases diagnosed by roentgen examination are much more uncommon than the other types, due in part to the difficulty of visualizing the region of the fistula or the gallbladder after the hepatic flexure has been filled with opaque media by the barium enema. With the enema examination the fistulous tract may be demonstrated as the barium or air is forced into it. In addition to this, spasm and irregularity, constriction, and mucous membrane

changes may be seen in the hepatic flexure of the colon. The mucous membrane changes are no doubt of the greatest value in the observation of this type of fistula. The folds will be indistinct, irregular, and often will simulate carcinoma. These changes have been ascribed to

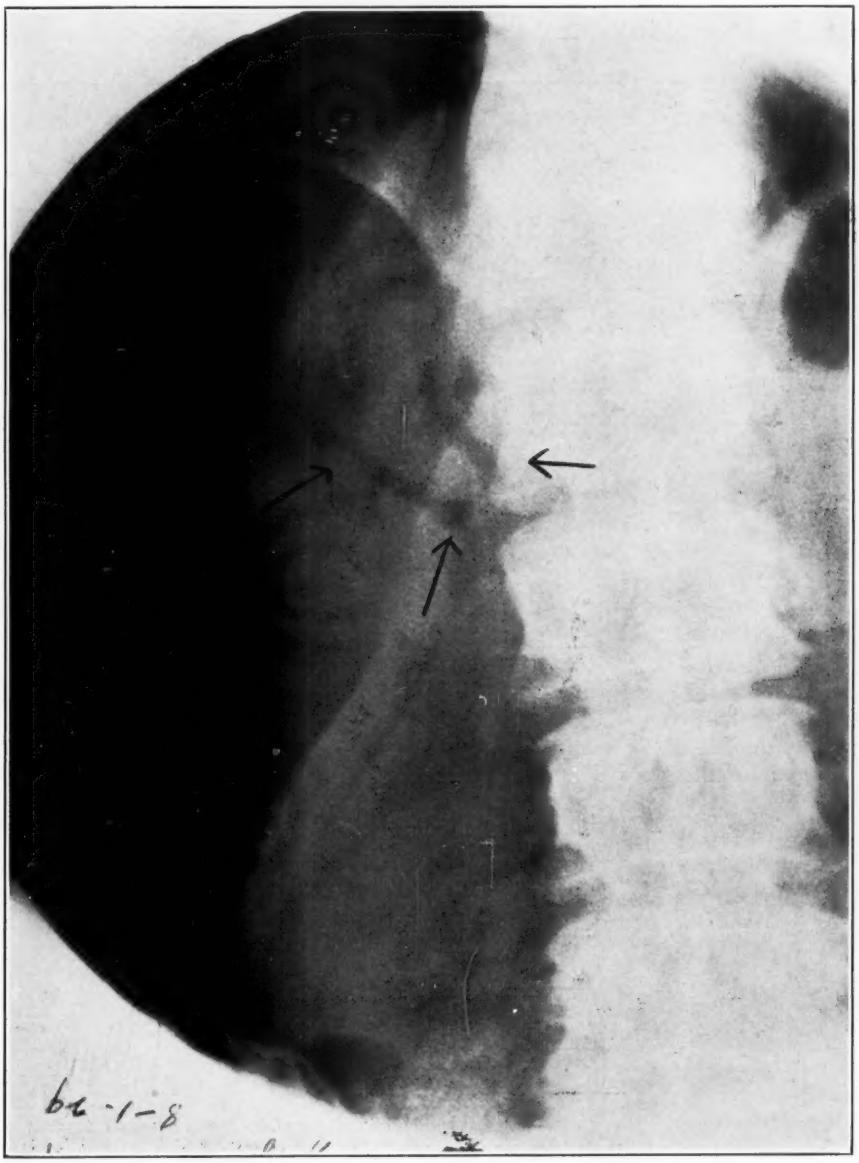

Fig. 4.—Case 2. Cholecystogram made Aug. 1, 1929, after passage of stone. Note the typical appearance of gas in the biliary ducts (arrows). The absence of the stone shadow seen in Fig. 3 should be observed.

the inflow of infected bile. The double contrast enema, that is, the inflation of the colon with air following the evacuation of the ordinary barium enema, is of great value in determining these changes. The barium meal may also be used and the filling of the colon by this

means occasionally reveals the fistulous tract. Here, as elsewhere, gas in the biliary ducts may be the first and only sign of the presence of a fistula.

In the cholecystogastric fistula the demonstration of the barium-filled tract, extending from the prepyloric area to the gallbladder region, is of prime importance. Mucous membrane changes with spasm,

Fig. 5.—Case 2. Roentgenogram after barium meal, showing regurgitation of barium into common duct (arrows), only the lower portion of which is filled. Note the mucous membrane changes in the second portion of the duodenum at the junction with the common duct (lower arrow).

contraction, and constriction of the prepyloric portion of the stomach are also observed. Spontaneous cholecystogastric fistulas are extremely rare. Rankin,[92] in 1932, found no reports of this type of fistula in the preceding ten years. His case was discovered when a follow-up examination was made twenty-four hours after the barium

meal, and showed a localized residue in the gallbladder region. Pohlandt's[88] case became evident when air was visualized in the bile ducts following the administration of dye for a gallbladder study. In the reported cases of this type a direct fistulous connection between the gallbladder and the prepyloric region of the stomach has been present. The exact type of fistula becomes apparent, obviously, when the fistula is filled with the contrast media. An examination one-half to one hour after the ingestion of the barium meal is important, since at this time the fistula may contain barium while the stomach itself has emptied.

Bronchobiliary fistulas are very infrequently found. Oliani,[83] in 1923, summarized 63 cases, but only 4 cases have been reported diagnosed by roentgen study. The fistulous tract usually leads from a liver abscess through the right diaphragm and into a branch of the right bronchial tree. Bile in the sputum constitutes the chief clinical finding. Gallstones and hydatid cysts are the usual causative factors. Injection of iodized oil into the bronchi occasionally will outline the fistulous tract. The tract will often heal spontaneously if the stone can be removed.

GALLSTONE OBSTRUCTION—A COMPLICATION OF INTERNAL BILIARY FISTULA

Gallstone obstruction is not an extremely rare condition, as illustrated by the fact that Edward,[28] in 1910, had collected 250 cases, Wagner,[115] in 1914, had collected 334, and by 1925, Moore[75] had collected 400 cases. The incidence is indicated by Bennett's[9] figures in which he showed that in 3,064 cases of intestinal obstruction, 28 were due to gallstones, a percentage of 0.9. In small series, Henry[44] and Powers[89] give the incidence at 3.0 per cent and 2.5 per cent respectively. Other authors have estimated the frequency of occurrence of intestinal obstruction due to gallstones as high as 1 in 15 cases (Fitz[32]) and as low as 1 in 280 cases (Bloodgood[14]). Martin[69] found only 16 cases of gallstone obstruction in 500,000 patients operated upon. In our own postmortem records there are only 11 cases of gallstone obstruction found in 19,474 autopsies, a percentage of 0.056. It appears from these figures that gallstone obstruction occurs much less frequently than internal biliary fistula. Since over one-half of the gallstones entering the gastrointestinal tract are passed spontaneously per rectum, this disassociation of fistula and obstruction is not surprising. In Judd's[51] series of 153 operated cases of internal biliary fistula, only one case of intestinal obstruction due to stones was found. However, in 11 of the 24 cases of internal biliary fistula found in our autopsies, some intestinal obstruction due to the passed gallstone was encountered. It is obvious that autopsy statistics are likely to show a higher percentage of gallstone obstruction than figures derived from surgical records because of the fatal character of this disease. Stones

usually enter the bowel through the cholecystoduodenal route; in 10 of 11 cases in our autopsies and in 69 per cent of Courvoisier's cases, entrance was gained through this tract.

It should be pointed out again that the finding of gallstone obstruction does not necessarily imply the presence of a true or active fistula. This may be due to a variation in the time of the onset of the obstruction following the entrance of the stone into the intestine. Frequently the length of time elapsing between the passage of the stone into the intestine and the development of the obstruction permit the fistulous tract to heal, only adhesions remaining between the gallbladder and the intestine. Angle[3] recently reported 1 case in which he estimated the stone had been present in the bowel for one year, and in 2 other cases the obstruction became acute after the stone had been present four months. Treves[112] also reported a case in which the gallstone remained in the bowel for ten years.

In addition to this, the possibility of obstruction occurring from the passage of stones through the common duct into the bowel, resulting in a stretched sphincter, but without a true fistula, as stated above, must be considered. Courvoisier[22] states that a stone large enough to cause intestinal obstruction occasionally passes through the common duct. In 7 of the 35 cases of intestinal obstruction due to gallstones, cited by him, the route taken by the stone was through the common duct itself. In 1 of these cases the common duct was dilated to the size of the gallbladder; in another, a stone 4 inches in circumference had passed through the common duct resulting in intestinal obstruction. It follows that although the surgeon may be unable to find a true fistulous tract between the biliary system and the intestinal tract, a dilated common duct may indicate the passage taken by the stone. While it is probable that most small stones enter the intestine through the common duct, those large enough to cause obstruction usually enter through a cholecystoduodenal fistula. The physical characteristics are probably more important than the size of the stone in determining the probability of obstruction. A relatively small stone, if sharp and angular, may cause a local spasm of the bowel wall and result in obstruction. This accounts for the cases of gallstone obstruction, terminating fatally, in which small stones have been found free in the lumen of the bowel. Sharp, irregular stones are the most likely to cause local changes in the mucous membrane, resulting in ulceration and perforation of the bowel. In one of the cases of gallstone obstruction in our postmortem records, a faceted calculus, 2.8 by 1.8 cm. in size, resulted in obstruction, causing death of the patient. In the other 10 cases of gallstone obstruction, impaction of the stone had occurred. Smooth, rounded stones, however, even if of considerable size, may pass through the intestinal tract with relatively meager evidence of obstruction. In one case of cholecystoduodenal fistula 2

stones, measuring 4 centimeters in diameter, were found in the small intestine; these, in spite of their size, had not caused intestinal obstruction. Stones entering directly into the colon are nearly always passed per rectum, regardless of size. Rolleston[97] states that stones over 1 inch in diameter are usually impacted in the small bowel at or near the ileocecal valve, and most authorities are agreed that the majority of obstructions occur in the terminal ileum. Crane[23] has commented on the infrequency of duodenal obstruction by gallstones, having found only 4 cases reported between 1923 and 1931; prior to 1912 Thompson[111] had found only 12 such cases reported.

Gallstone obstruction occurs most frequently in females, as one might expect. Courvoisier[22] studied 102 cases, 69 per cent of which were females; 82 per cent of his cases were over fifty years of age and 61 per cent over sixty years. In 11 cases of gallstone obstruction in our autopsy series all the patients were females and the average age was sixty-six.

The clinical diagnosis of gallstone obstruction is apparently a very difficult one. Characteristically, these cases exhibit a tendency to subchronic or chronic symptoms of obstruction, with periods of more or less obscure abdominal discomfort alternating with periods of relative freedom of symptoms. The pain is ascribed to spasm of the bowel around the stone, and the slow passage of the stone downward produces a clinical course of intestinal colic with unusual variations. The symptoms often are insufficient to cause concern until a few days after the passage into the bowel occurs, and definite signs may be delayed even longer. When the impaction of the stone finally does occur, persistent vomiting with intermittent colicky pain, characteristic of intestinal obstruction, become prominent features. This obscure clinical course often results in delay on the part of the patient in seeking medical advice. Schéle[100] has commented on the unusual period of time elapsing from the onset of symptoms to the admission of the patient to the hospital. The relation of this time factor to the mortality rate is self-apparent. Gallstone obstruction should be thought of in any case in which there is a major abdominal catastrophe and a history of previous attacks of biliary colic. The mortality from this disease has been estimated at from 56 to 92 per cent by various authors,[44, 69, 74, 75, 78, 103] a much higher rate than in cases of obstruction due to other causes. This is, no doubt, due to the delay in diagnosis incident to the difficulty of estimating the clinical symptoms.

ROENTGENOLOGIC DIAGNOSIS

The preoperative roentgenologic diagnosis of intestinal obstruction due to gallstones has been made in very few cases. So far as we can determine[15, 23, 52, 63, 66, 86, 100] only 7 such reports appear in the literature. Failure to consider the possibility of biliary calculi as the cause

of obstruction results in this rarity of roentgen diagnosis. Likewise, the justifiable reluctance in the use of a barium meal by mouth, in cases in which intestinal obstruction is a possibility, often results in the roentgenologist's failure to determine the cause of the obstruction. There can be little doubt that a number of the more obscure cases of ileus are traceable to the presence of a stone in the intestinal tract.

It is well known that from 10 to 20 per cent of the adult population have calculi in the biliary tract, and these frequently enter the intestines. In the past, however, only those cases with stones causing a complete intestinal obstruction requiring surgery have been brought to the surgeon's and roentgenologist's attention. Over 50 per cent of stones, however, do not cause a high grade obstruction, but give rise to some occlusion of varying degree, and finally are passed spontaneously by rectum. In this group, it may be expected that x-ray diagnosis of stones in the intestinal tract will be made with greater frequency in the future.

The chief roentgenologic findings in gallstone obstruction may be due to three factors. The first is concerned with the ordinary signs of the fistula which preceded the obstruction. In this, as outlined above, the most important sign is a visualization of gas in the biliary system. Second, the gallstones themselves may be detected in the roentgenograms of the abdomen. Finally, there is, of course, the roentgenologic evidence of partial or complete obstruction of the intestine.

When the etiology of an intestinal obstruction is in doubt and there is any indication in the clinical story which might implicate the gallbladder, a localized film of the gallbladder region should be made, in addition to the usual abdominal films which are made now with great regularity in cases of intestinal obstruction. If the gallstone is of the opaque type, it may be readily demonstrated either in the gallbladder region or possibly in some remote portion of the abdomen where the obstruction has occurred. Unfortunately, however, some 75 or 80 per cent of the stones which are actually present cannot be well seen in the ordinary films, either of the abdomen or of the gallbladder region itself. The most important sign which will be revealed by these localized films of the gallbladder region is the presence of gas in the biliary system.

In the early stages the obstruction may be high in the intestinal tract, and repeated films of the entire abdomen will show a gradual change in the position of the intestinal gas indicating the changing site of the obstruction. Unusual variations in the degree of intestinal distention with gas may also be noted. In all the cases previously reported in the literature, the patients had a barium meal by mouth

and later showed a circular filling defect in the intestine due to displacement of the contrast medium by the stone. This gives an appearance similar to that of a tumor of the small bowel. Barium meal studies, however, should not constitute a routine procedure in cases of obscure obstruction because of the possibility that the barium itself may increase the degree of obstruction. Careful study of films made

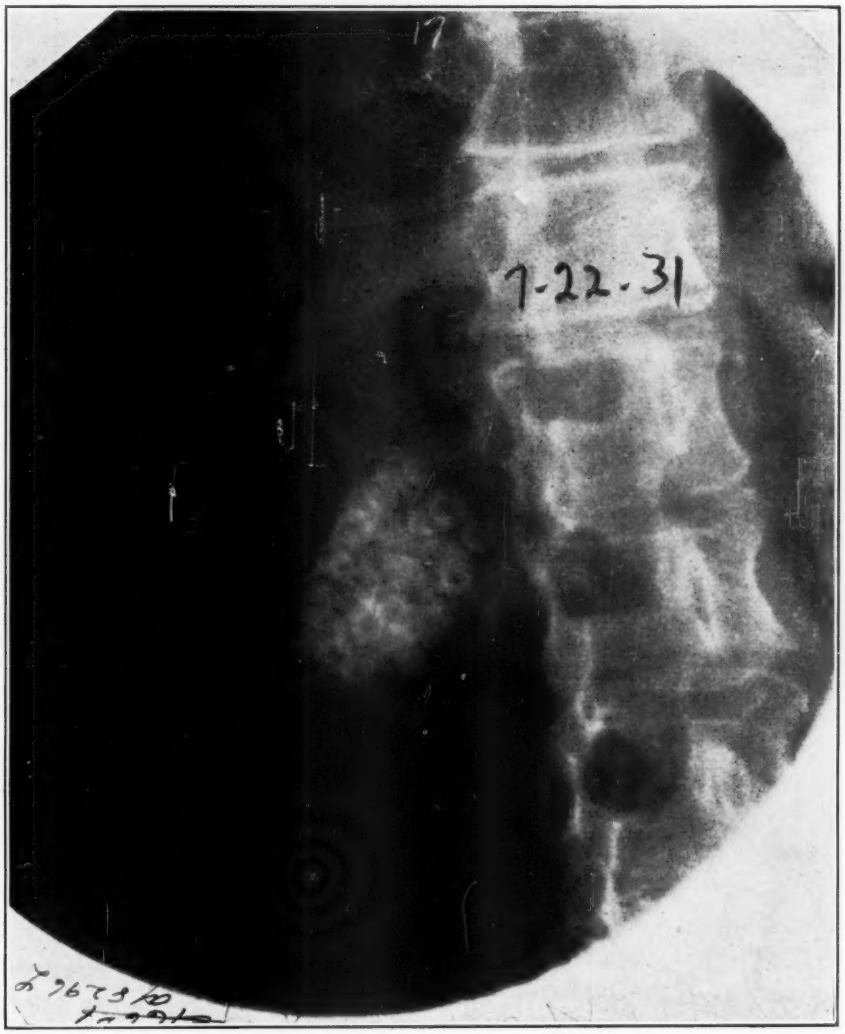

Fig. 6.—Case 3. Roentgenogram made July 22, 1931, showing large mass of typical calcified calculi in gallbladder region.

without contrast media should reveal sufficient findings to make the diagnosis clear. The possibilities of diagnosis and the chief roentgenologic findings are well illustrated in the following case.

CASE 3.—A woman, aged sixty-two years, was first seen in June, 1931. For thirty-one years the patient had had recurrent attacks of right upper quadrant pain with scapular radiation, associated with jaundice, food distress, and occasionally

vomiting. A cholecystogram showed a large number of stones in the gallbladder (Fig. 6). Operation was advised, but the patient refused. The periodic gallbladder attacks continued. On July 15, 1932, the course of events suddenly changed, as the patient suffered an unusually severe attack of pain, and the usual jaundice did not appear. The picture was further complicated by the development of persistent vomiting, which continued until Aug. 11, 1932, when the patient was admitted to the hospital in an extremely toxic and dehydrated condition. The icterus index upon admission was 12; the stool was positive for urobilin. The clinical im-

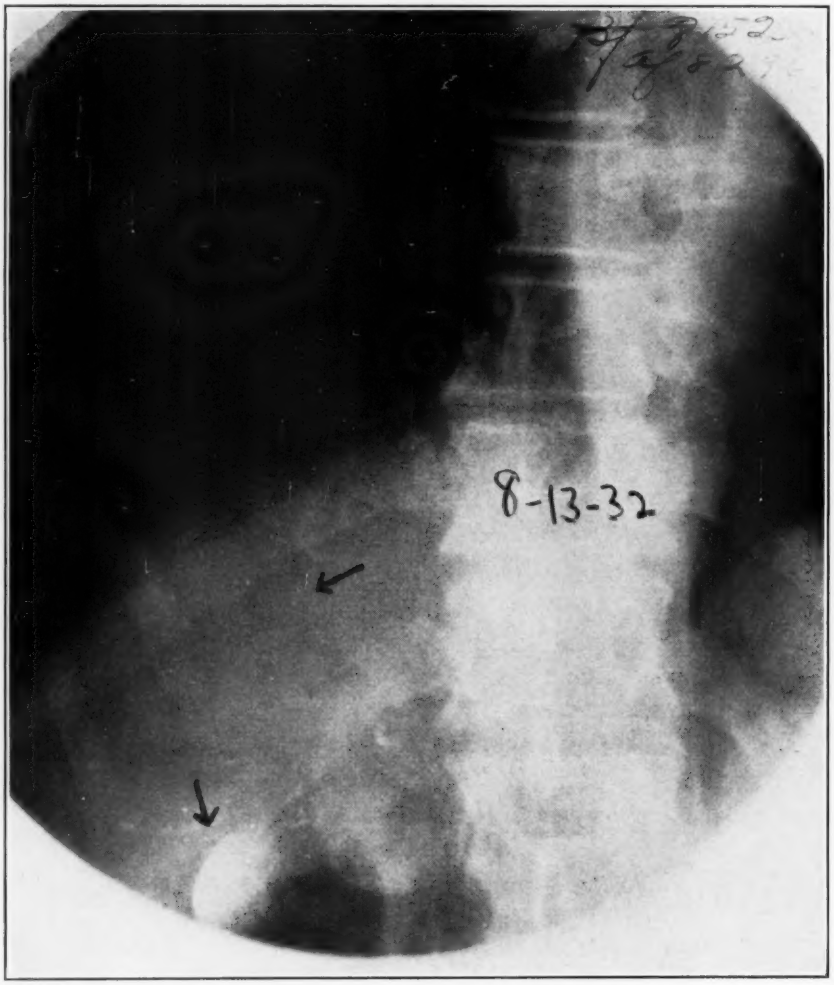

Fig. 7.—Case 3. Roentgenogram made Aug. 13, 1932, showing gas in biliary ducts (upper arrow) and paraduodenal accumulation of barium in gallbladder area (lower arrow). Note absence of gallstone shadows shown in Fig. 6.

pression was pyloric obstruction. A barium meal study of the stomach and duodenum on Aug. 12, 1932, showed a right paraduodenal shadow of barium, rounded in contour, representing what was believed to be the gallbladder. A single film of the gallbladder region on the following day disclosed gas in the bile ducts and absence of the large mass of gallstones previously reported (Fig. 7). Nasal suction was instituted for relief of gaseous distention of the small bowel. Clinical improvement followed, and on Aug. 18, a flat plate of the abdomen revealed a

large mass of stones in the left lower quadrant (Fig. 8). Comparison with the previous film of the gallbladder region revealed a definite similarity to the stones previously visualized in the gallbladder. Gaseous distention of the small bowel was also shown, but the obstruction appeared to be only partial.

A barium meal study of the stomach and duodenum on the next day showed extension of barium from the second portion of the duodenum into a tract leading

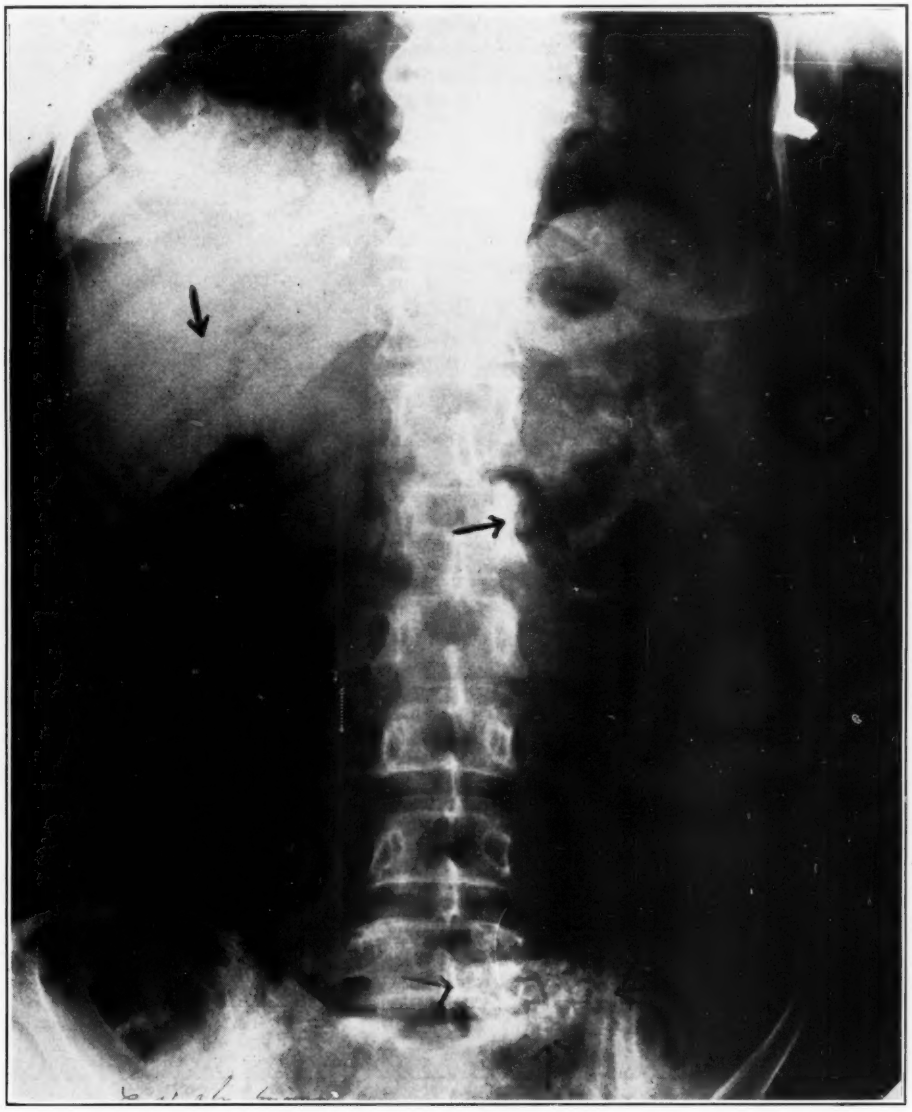

Fig. 8.—Case 3. Roentgenogram of abdomen, showing gas in dilated small intestine suggesting partial obstruction. Gas is also present in large amounts in the colon. Note the mass of gallstones, exactly similar to that shown in Fig. 6, in the left lower quadrant (arrows). The diagnosis of internal biliary fistula and gallstone obstruction should have been made from this single film.

into the gallbladder area (Fig. 9). A rounded barium shadow was visible in the gallbladder region. The roentgenologic diagnosis was: "Biliary fistula extending from the gallbladder fossa into the duodenum formed by the passage en masse of a large number of gallstones, with secondary obstruction of the small bowel due to

the mass of gallstones.'' Repeated flat plate examinations of the abdomen showed a shifting of the position of the stones (Compare Figs. 8 and 9). After nasal suction, practically no gas was present in the small bowel, and the patient was slightly improved. (The critical condition of the patient did not warrant operation.) Suddenly, on Oct. 2, 1932, two and one-half months after the onset of symptoms of

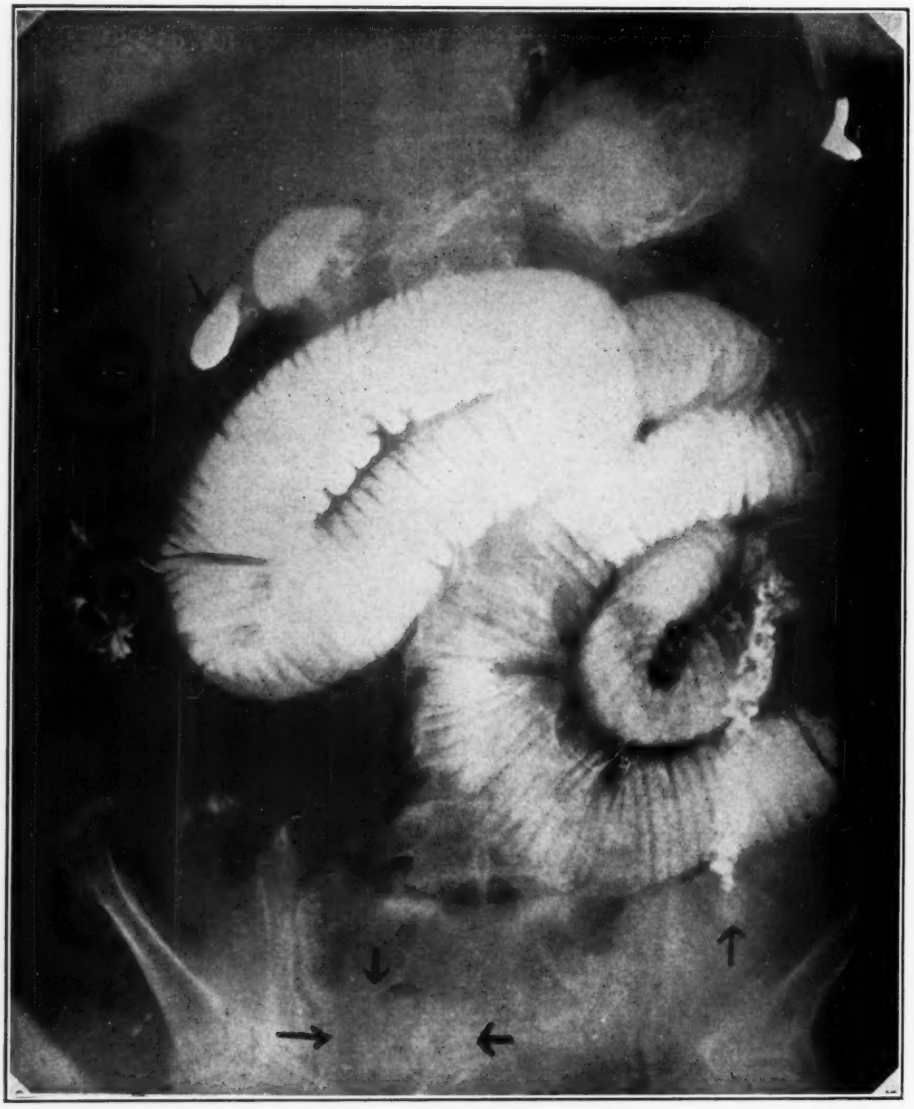

Fig. 9.—Case 3. Roentgenogram after barium meal, showing typical appearance of cholecystoduodenal fistula. Note paraduodenal accumulation of barium communicating with duodenal bulb. The dilated, obstructed small bowel is well demonstrated (arrow), and the mass of stones can now be seen in the pelvis to the right of the midline (lower arrows).

obstruction, during a period of beginning improvement, the patient experienced severe right lower quadrant pain, with marked tenderness, rigidity, and vomiting. Death occurred Oct. 4, 1932.

Postmortem Examination.—A diffuse purulent peritonitis was present. The ventral surface of the gallbladder, near the fundus, was attached to the duodenum.

A fistula, the orifice of which was 2 centimeters in diameter, lead into the duodenum. Food particles were present in the gallbladder. The cystic duct was patent; the common duct was thicker than normal and the entire lower one-half was filled with concretions.

A large immovable mass of gallstones was found in the lower ileum firmly filling the lumen of the bowel. There were two sharp projections present, which had caused perforation of the bowel. The stones were firmly matted together by some form of calcareous material. The mass could not be broken apart by moderate manipulation.

COMMENT

The observation of barium in the gallbladder fossa, following the gastrointestinal study, was the first clue to the diagnosis of a fistulous connection between the biliary system and the intestinal tract. Subsequent visualization of gas in the biliary ducts confirmed this diagnosis. The demonstration of the mass of gallstones in the left lower quadrant indicated the diagnosis of gallstone obstruction. Later, following a barium meal by mouth, the fistulous connection to the gallbladder area was visualized, secondary changes in the duodenum were demonstrated, and the intestinal obstruction was confirmed. Absence of the previously visualized mass of gallstones, combined with the clinical story of obstruction, immediately suggested intestinal obstruction due to gallstones. Giving the barium meal was an error and was really unnecessary in making the diagnosis.

The roentgenologic studies explain satisfactorily the clinical course of events in this case. The history of uniform gallbladder attacks with jaundice over a period of thirty-one years, suddenly changing to an unusually severe attack of pain with the absence of jaundice is suggestive of fistula formation. Relative freedom from symptoms thereafter would have been expected in an uncomplicated case of biliary fistula. The rapid onset of an unusual type of intestinal obstruction, however, combined with the long history of gallbladder attacks, and with the occurrence of a major abdominal catastrophe, strongly implies the presence of gallstone obstruction as well as the biliary fistula. A single flat plate of the liver area, showing gas in the bile ducts, would have accounted for the entire picture.

This case is typical of spontaneous internal biliary fistula of the cholecystoduodenal type, with intestinal obstruction due to gallstones as a complicating factor. The passage of a mass of gallstones of this size directly into the duodenum is, however, uncommon. Passage of a mass of this size directly into the colon would be less unusual, and in such an instance obstruction would have been less likely to occur. It is interesting to note that the stones were present in the intestinal tract for two and one-half months. During this time, the original fistulous orifice had contracted considerably and probably would have

closed at a later date. A smaller stone probably would not have resulted in intestinal obstruction, and the nature of the pathologic process here demonstrated might never have been known.

SUMMARY

The general findings in spontaneous internal biliary fistula are reviewed and the literature is brought up to date. The incidence, pathology, and clinical findings are discussed.

To the previously reported cases observed at autopsy, 24 cases are added.

Eighty-three cases, roentgenologically diagnosed, have been collected from the literature. To these are added 8 new cases.

The roentgen findings in this condition are detailed and 2 cases, roentgenologically diagnosed, are reported in detail. The value of the roentgen examination is emphasized.

The relationship of gallstone obstruction to internal biliary fistula is discussed and the roentgenologic findings are detailed. Seven previously reported cases in which the diagnosis was made by x-ray examination have been collected. To these is added a case of gallstone obstruction with a cholecystoduodenal fistula, roentgenologically diagnosed.

CONCLUSIONS

Spontaneous internal biliary fistula is more common than autopsy or operative records would indicate.

The diagnosis can readily be made by roentgen examination alone and often the exact anatomic site of the fistula can be predicted by this means. The presence of gas or barium in the biliary system, the demonstration of the barium-filled fistula itself, the absence of a normal gallbladder shadow on cholecystography, and the presence of mucous membrane changes in the gastrointestinal tract are the chief roentgenologic findings.

Gallstone obstruction is a complication of internal biliary fistula which should always be considered in atypical cases of intestinal obstruction. It is diagnosed clinically with great difficulty.

Roentgen examination of the gallbladder region particularly, as well as of the whole abdomen, in cases of suspected intestinal obstruction, may reveal evidences of a biliary fistula and thus make the origin of the obstruction clear. This type of examination should be made in all cases with symptoms of obstruction of obscure origin.

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POSTOPERATIVE WOUND INFECTIONS AND THE USE OF SILK: AN EXPERIMENTAL STUDY

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CLINICAL experience has shown that in clean wounds postoperative infection occurs less frequently where fine silk has been employed as suture material than where catgut has been used.[1-3] This difference may be attributed to the fact that silk is much less irritating to the tissues and does not itself provide a favorable medium for the growth of bacteria. The silk wound is thus better able to tolerate a slight bacterial contamination which might in the catgut wound result in suppuration. The observations and statistics which have led to these conclusions are, however, open to the just criticism that they are necessarily compiled from more or less uncontrolled data. Obviously, we cannot in the clinic deliberately contaminate wounds to observe their resistance to infection; and where suppuration unfortunately follows a clean operation, it is impossible to control the factors which attended the initial contamination.

As the fear of the consequences of infection still constitutes the chief obstacle to a more general adoption of the silk technic, it seemed desirable to study more carefully the comparative healing of contaminated silk and catgut wounds. We have, therefore, investigated this problem in the experimental laboratory and have been able to demonstrate by controlled observations the superior resistance of silk wounds to infection. We have, likewise, been able to confirm an observation previously made in the clinic,[3] which is contrary to accepted opinion; namely, that suppurating silk wounds may in certain instances completely heal without the removal or the spontaneous discharge of the fine silk sutures and ligatures.

METHOD

Healthy dogs were anesthetized with intravenous nembutal, and the usual hospital operating room technic was followed. Two abdominal incisions were made on either side of the midline through the fascia and muscle to the peritoneum. A measured amount of a bacterial suspension was introduced into both wounds and closure made in layers uniformly using silk on the right side and catgut on the left side. On the silk side, interrupted C silk (No. 9) was used for the fascia and interrupted A silk (No. 4)* for the subcutaneous layer and for ligating vessels. On the cat-

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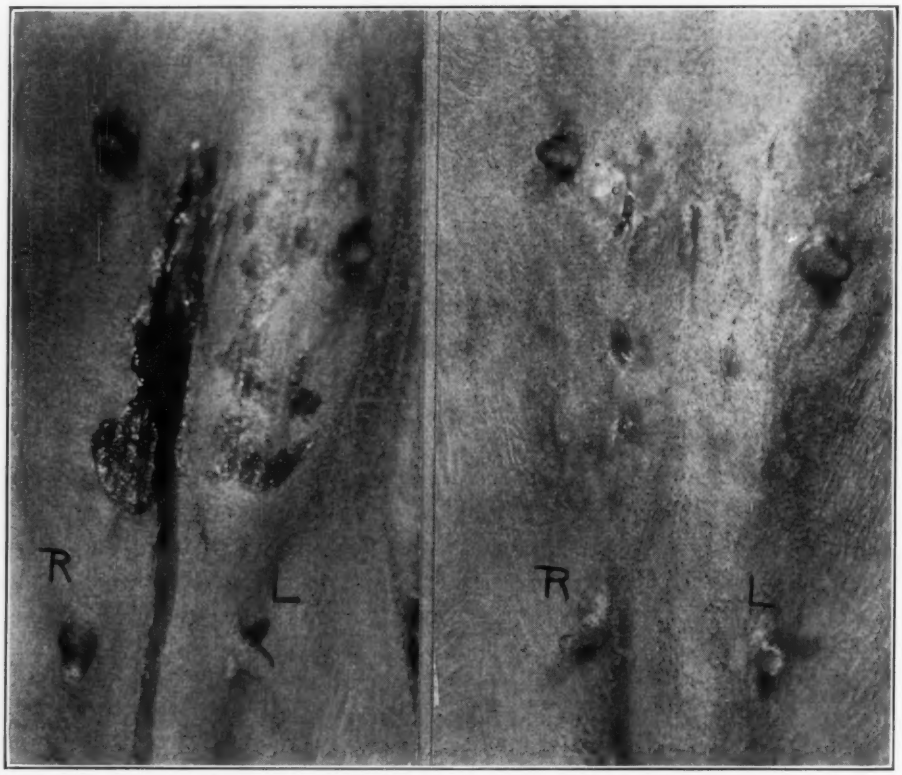
*"Champion Surgeon's Silk," Gudebrod Brothers Silk Company.

gut side, interrupted No. 1 chromic was used for the fascia and interrupted No. 00 chromic* for the subcutaneous layer and for ligatures. The skin was sutured with silk on both sides. In a number of dogs, the incisions were extended through the peritoneum which was closed before introducing the bacteria. In these, the peritoneum was, as a rule, closed by a continuous suture of No. 00 chromic catgut on the silk side as well as on the catgut side. In two experiments, however, the peritoneum on the silk side was closed by a continuous suture of C silk. As we shall see later, the use of a continuous silk suture in the presence of infection proved to be undesirable.



A. *B.*

Fig. 1.—Photograph showing the comparative healing of infected wounds which have been sutured with catgut on the right side (left side in photograph) and with silk on the left side. *A*, on the fourth postoperative day; *B*, on the twenty-first postoperative day. The catgut wound broke widely open and discharged a thick purulent exudate. The silk wound, although it became red and swollen, did not suppurate. Postmortem dissection three months later showed the silk sutures in place without gross evidence of infection.

A convenient and effective method of infecting the wounds was the introduction of a suspension of the animal's feces which was obtained from the rectum before the operation. This was mixed with water and strained through gauze. Care was taken to inoculate both wounds equally and simultaneously by a measured amount of the well-mixed suspension applied on the surface of the open wounds through a small

*"Boilable Germicidal Catgut," Davis & Geck, Inc.

hypodermic needle. Variations in the procedure were made in several of the experiments. In one experiment *Staphylococcus aureus* was used and in another, a mixture of *Staphylococcus aureus* and *Streptococcus hemolyticus*. During the period of healing, the wounds were protected with dressings. When a wound became distended with

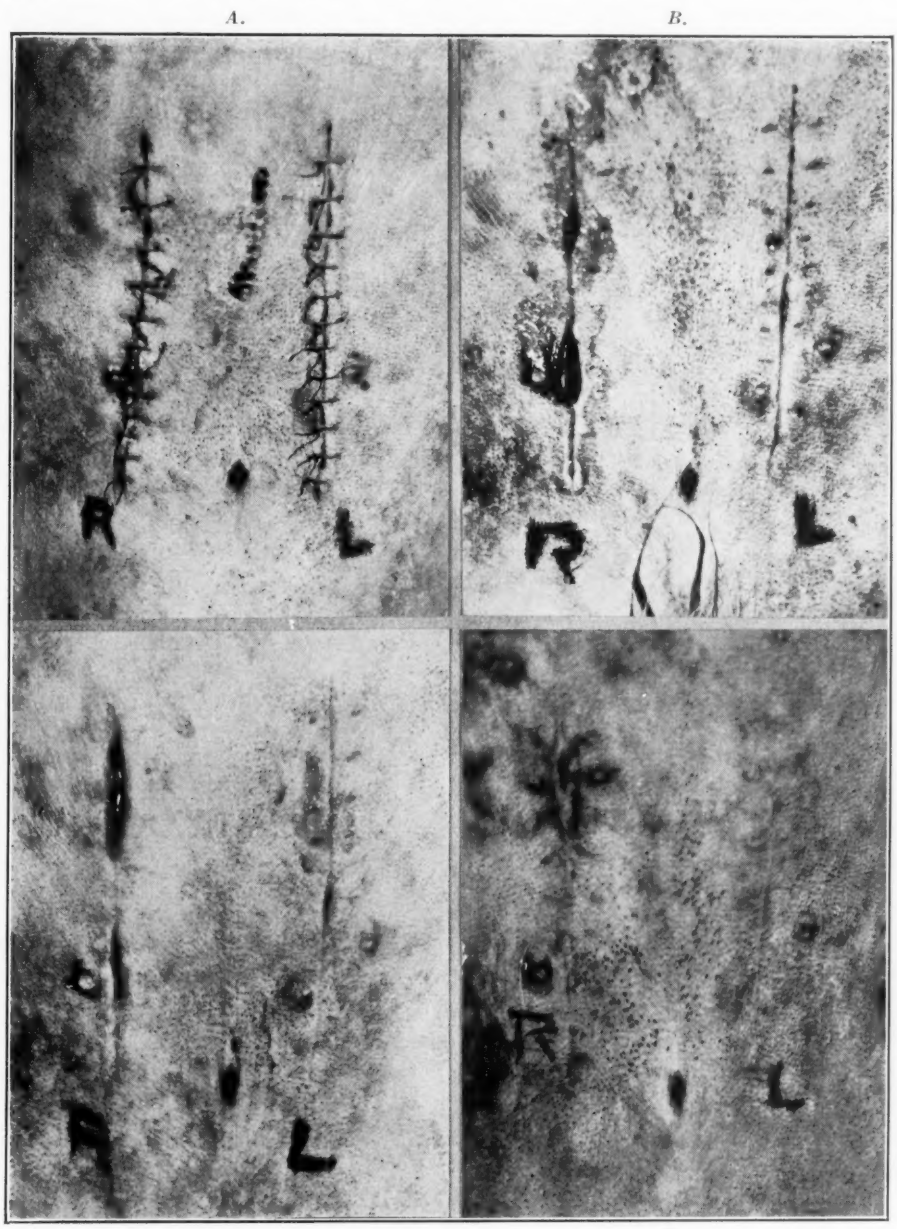


Fig. 2.—Photograph showing the comparative healing of infected wounds sutured with catgut on the right side (left side in photograph) and with silk on the left side. *A*, on the first postoperative day; *B*, on the second postoperative day; *C*, on the fifth postoperative day; *D*, on the eighteenth postoperative day. The wound sutured with catgut broke widely open and discharged a thick purulent exudate; whereas, the wound sutured with silk showed only slight separation of the wound edges and did not suppurate. Note the contrast (*D*) between the almost invisible wound on the left side (right side in photograph) and the scarring on the right.

purulent material, this was liberated through a small opening in the line of the incision. No other treatment was given. The wounds were never opened widely, and no sutures, aside from those in the skin, were removed.

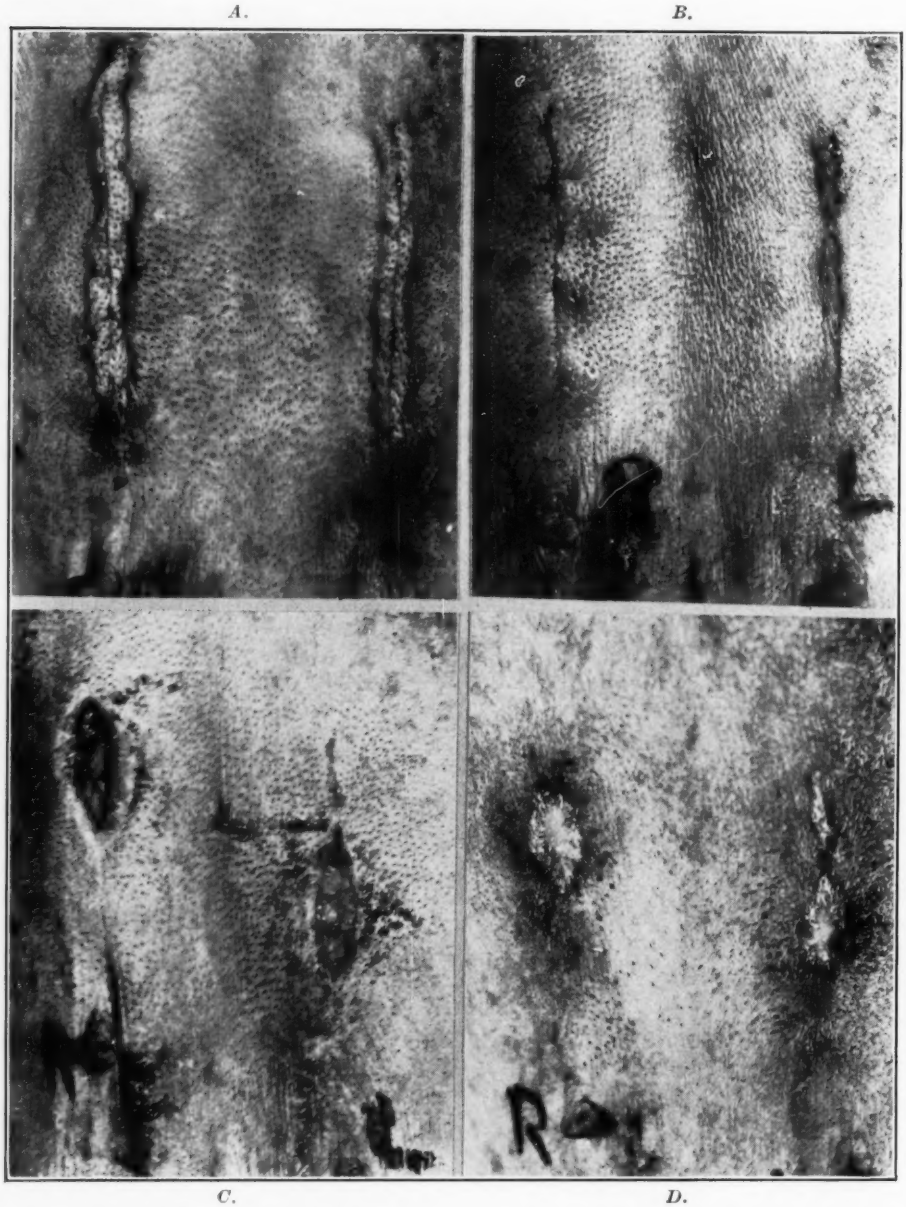


Fig. 3.—Photograph showing the comparative healing of heavily infected wounds sutured with catgut on the right side (left side in photograph) and silk on the left side. *A*, on the first postoperative day; *B*, on the third postoperative day; *C*, on the seventh postoperative day; *D*, on the twenty-eighth postoperative day. Although the catgut wound showed an earlier and more severe reaction (*B*), both wounds suppurated. Note that healing occurred just as promptly in the wound containing buried silk as in the wound where catgut was used. Postmortem dissection two months later showed the silk sutures in place with very little reaction of the surrounding tissues and with no gross evidence of infection.

RESULTS

The comparative healing of heavily infected silk and catgut wounds was studied in ten experiments. Gross suppuration occurred in the catgut wound in every instance; whereas, the silk wound in four experiments healed without suppuration (Figs. 1 and 2). In four experiments, the silk wounds suppurated, but the wounds showed considerably less reaction than the corresponding catgut wounds, and the suppura-

Fig. 4.—Photomicrograph of a heavily infected wound which was closed in layers with fine silk sutures, four months after operation. Gross suppuration occurred but healing was not delayed by discharge of sutures, and there were no persistent sinuses. Note the well-encapsulated black silk suture (*A*) and the almost invisible scarring of the line of incision (×12).

tion occurred at a later date (Fig. 3). In the remaining two experiments, both the silk and the catgut wounds showed about the same reaction and both suppurated at about the same time.

We were particularly interested in following the healing of the silk wounds in which suppuration occurred. All except one of them healed as quickly as the corresponding catgut wound, the average period of healing being twenty-five days. The single exception was one of the two

instances in which a continuous silk suture was used to close the peritoneum. In this case, a small sinus persisted for seven months, at which time the animal was sacrificed and dissection of the wound showed a long suture lying at the bottom of the sinus. The fine interrupted silk sutures, however, were all in place and were not in communication with the sinus.

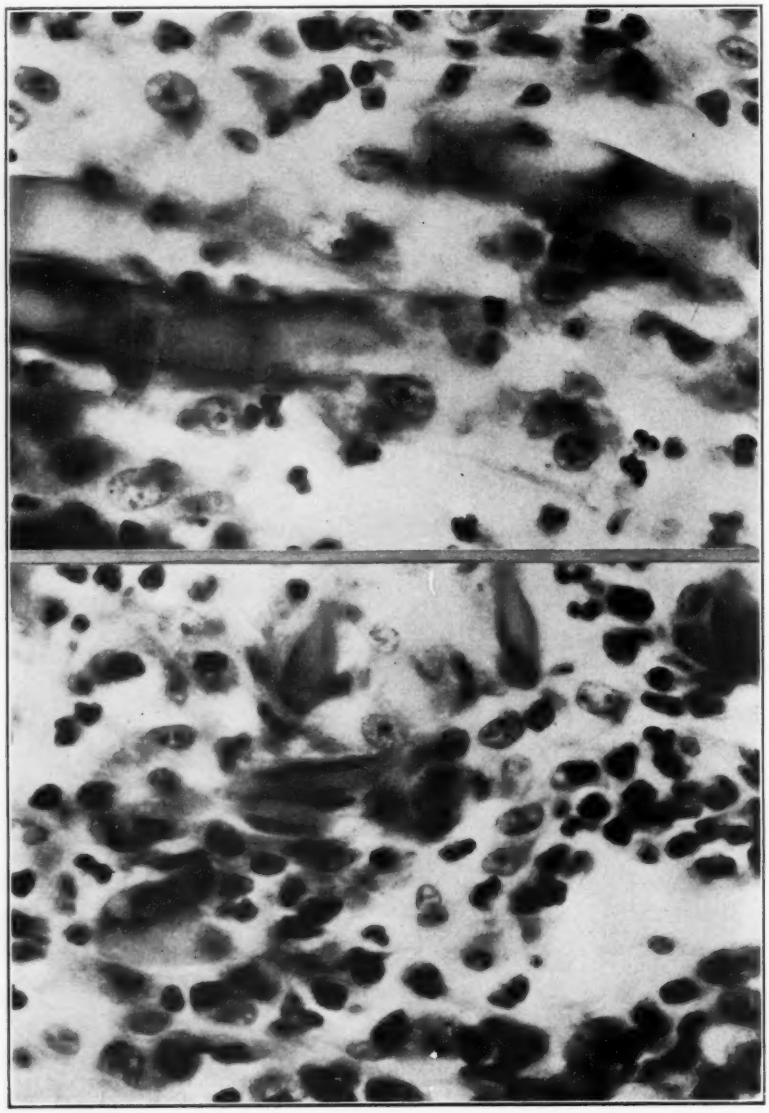


Fig. 5.—Higher magnification of the encapsulated silk suture shown in Fig. 4. Although there are still polymorphonuclear leucocytes present, the strands of silk are surrounded by fibroblasts and mononuclear cells (×900).

There were eight* silk wounds in which suppuration occurred. All of these, with the exception of the above instances, healed firmly within

*In addition to the six suppurative wounds out of the series of ten experiments mentioned previously, there were two wounds in a secondary experiment, both sutured with silk and both heavily inoculated with feces.

twenty-eight days and remained healed as long as observed for intervals up to twelve months. Seven of the wounds were dissected postmortem. The silk sutures and ligatures were found in place with little or occasionally with no gross tissue reaction. Those in the muscle showed no reaction, whereas, the bits of black silk in the fascia and subcutaneous tissues were frequently found to lie in a tiny area of fibrosis or of yellowish jellylike material. In no case, however, was an abscess found. In one experiment, aerobic and anaerobic dextrose broth cultures were made from the tissues about the silk sutures twelve months postoperatively. No growth was obtained.

Histologic studies of the silk wounds, which were heavily infected, gave definite evidence that satisfactory healing had occurred without discharge of the silk sutures (Figs. 4 and 5).

In one of the experiments, the postmortem dissection disclosed an interesting finding. Both the silk and the catgut wounds had suppurated and healed. Seven weeks later the animal was sacrificed. The silk wound showed all the sutures in place with a small amount of the jellylike material about several of them, but, no fluid or purulent material. The catgut wound, however, contained three indurated areas 5 millimeters in diameter lying in the subcutaneous layer, each containing a small firm catgut knot lying in cloudy fluid. The catgut did not appear altered by its two months' residence in the tissues. Apparently catgut may occasionally, even in the presence of infection, resist absorption and remain unchanged in the tissues for a considerable period. This concurs with our clinical experience, for we have observed several instances in which complete healing has been delayed by bits of unabsorbed catgut.

CONCLUSIONS

1. Controlled experimental studies on dogs show that operative wounds repaired with silk tolerate bacterial contamination better than similar wounds repaired with catgut.

2. The healing of experimental suppurating wounds is not appreciably delayed by the presence of buried silk sutures and ligatures provided a fine grade of silk is used, the sutures are cut close to the knot, and no continuous sutures are employed.

3. Experimental suppurating wounds repaired with fine silk may heal completely without the removal or the spontaneous discharge of the silk sutures.

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PNEUMOCOCCUS PERITONITIS*

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A SURVEY of various reports in the literature reveals considerable discrepancy in the various features of pneumococcus peritonitis, even in the consideration of such important features as treatment. Some authorities advise immediate operation in the early stage of the disease, whereas others prefer to wait until the infection has become localized to an encapsulated abscess. There is likewise disagreement as to the diagnostic difficulties encountered; a great part of this difficulty is no doubt accounted for by the marked variability in the clinical manifestations of the disease. Because of the above features, a study of the available cases† (twenty-six including those accompanied by nephrosis) has been made.

ANALYSIS OF CASES

Search through the records of the medical and surgical service of the St. Louis Children's Hospital during an eighteen-year period has revealed a total of 26 children with pneumococcus peritonitis. They may be divided into three groups as outlined in the following table:

TABLE I

	TOTAL NO.	DIED	SURVIVED
Peritonitis developing in the absence of demonstrable primary lesion	9 { 7 F, 2 M }	4	5
Peritonitis presumably secondary to upper respiratory infection	7 { 6 F, 1 M }	3	4
Peritonitis developing in presence of ascites due to nephrosis	10 { 5 F, 5 M }	7	3
Total mortality 54 per cent. Mortality exclusive of nephrosis group, 44 per cent.			

In the first group of 9 patients, the infection developed in children who were presumably entirely healthy until the manifestations (consisting primarily of abdominal pain, vomiting, and fever) of peritonitis were noted. Contrary to the observations of many authors on the subject of pneumococcus peritonitis, these children did not appear to belong to a lower strata of society, and seemingly had the advantage of

*Credit is extended J. B. Jones who assisted in assembling data on many of the patients.

†These patients represent cases of pneumococcus peritonitis observed in the St. Louis Children's Hospital over a period of 18 years. Sincere thanks are extended to Dr. A. F. Hartmann for the privilege of including many cases from the medical service.

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average living quarters. In the second group, the type of upper respiratory infection which preceded the onset of peritonitis by one to six days was variable, but consisted chiefly of pharyngitis and coryza as is noted so consistently in the so-called "common cold." Although pneumonia developed in 4 of these 7 cases, only in one instance did the pneumonia appear to develop before the peritonitis. In the group of 10 children with ascites due to nephrosis, the infection was ushered in rather suddenly with fever, abdominal pain, vomiting, often diarrhea, but seldom with any premonitory symptoms. Of the entire group of 26 cases, 14 died—a mortality of 54 per cent. As has been noted by other observers, however, the mortality in children with nephrosis with superimposed pneumococcus peritonitis is higher than in those who were healthy at the time of contracting the peritonitis. The mortality exclusive of those with nephrosis was 44 per cent.

This series of patients is too small to determine the relative merit of, or damage sustained by, operation in the early stage of the disease. Operation was performed in the early stage only in four instances; on each occasion the operation was performed on the assumption that appendicitis or early peritonitis was present; the correct diagnosis was not made until the abdomen was opened. Operation was not performed on any of the patients with nephrosis. Of the 4 children operated upon, 2 died. This mortality of 50 per cent is undoubtedly misleading, because this group of 4 patients, in reality, represented milder cases than the average. It has been our experience that, when the disease starts locally simulating appendicitis, the infection is less severe. Five children were operated upon because of the development of a local abscess, several days or a few weeks after the onset of the disease. All of these patients survived, indicating that if the patient survives the acute stage of the disease, recovery is to be expected even though abscesses develop, as they commonly do.

Routine cultures of the vaginal tract were not made, but a vaginal discharge was noted in only one child. In this instance, however, the vaginal discharge did not appear until several days following the onset of manifestations of peritonitis. Culture revealed pneumococci in the discharge.

Data regarding the typing of the organism were not obtainable in all cases. The incidence of Group IV organisms was slightly greater than Type I. The mortality in the group of cases with Group IV organism was slightly greater than with Type I. Antipneumococcus serum was used in several instances with evidence of favorable effect in only a few cases. This form of treatment will be discussed later in greater detail.

Diarrhea was a common manifestation (being noted in 30 per cent of the patients exclusive of the nephrosis group), and with few exceptions occurred early in the disease. In fact, on one or two occasions it preceded other manifestations so definitely as to be seriously considered as a possible factor in the pathogenesis.

The tendency toward spontaneous perforation of the abdominal wall at the umbilicus has been noted by numerous observers. In this series of patients the infection broke through the umbilicus with discharge of pus on four different occasions, but did not occur in the nephrosis group.

INCIDENCE

Pneumococcus peritonitis is not a common disease, but occurs frequently enough to demand a thorough knowledge of the subject by the surgeon, as well as the pediatrician. During the eighteen-year period at the St. Louis Children's Hospital when 26 cases were encountered, there were 445 cases of acute appendicitis. The disease is therefore only 4.5 per cent as common as acute appendicitis in this particular locality. It is apparently much more common in Germany and France, judging from the number of cases reported from the various clinics there. Female children between the ages of two and ten years are most commonly afflicted.

PATHOGENESIS

There are three prominent possibilities as portals of entry for the organism. Each of these avenues of infection has its proponents in the literature.

1. The theory of blood-borne transmission is undoubtedly an important one. Of the group of children whose peritoneal infection seems to have developed in this manner, upper respiratory infection (particularly rhinitis, tonsillitis, and pharyngitis) appears to be the most common portal of entry for the organism. In the present series of cases, almost half (exclusive of the cases developing in the presence of nephrosis) gave a history of a significant infection of this type, preceding the onset of peritoneal symptoms by one to five days. In a series reported by Lipschutz and Lowenberg,[1] they noted that 90 per cent gave a history of upper respiratory infection preceding the abdominal symptoms. In a large percentage of their cases and in other series as well, the same type of pneumococcus has been isolated from the throat of the patient as was found in the peritoneal cavity. Montgomery[2] has emphasized the invalidity of the argument that since the disease is so uncommon in pneumonia, it cannot be blood-borne, by remarking that "metapneumonic joint infections are also rare but they are undoubtedly due to infection from the blood stream."

2. Because of the proximity of the intestine to the peritoneal cavity, transmission of the organism from this source would appear likely, particularly since diarrhea is such a constant accompaniment of the manifestations of the disease. Diarrhea was noted in 30 per cent of the author's series, but in other series it has been reported in a much higher percentage. The most serious obstacle in this theory of transmission lies in the fact that the diarrhea so frequently develops the day

following the onset of peritoneal symptoms. Pneumococcus peritonitis has been produced on numerous occasions in animals by feeding cultures of pneumococci by mouth, but there is a sufficiently large number of failures to make the theory unconvincing.

3. McCartney and Fraser[3] have presented evidence to prove that transmission by the genital route occurs commonly. In their series of 56 cases, all but 12 were girls. They remark that in every instance of infection in the male, a primary source (pneumonia in 11 of the 12 cases) of infection was demonstrable. They also noted that their patients came from a low stratum of society, and assumed that uncleanliness was an important factor in contamination of the vagina with transmission upward into the peritoneal cavity through the uterus and tubes. This observation (occurrence in the low social strata) is not confirmed by the reports of many authors, including the present one.

The pathogenesis of infection in children with nephrosis may be somewhat different from that in healthy children. Hartmann[4] has called attention to the fact that usually these children are those with poor resistance and are frequently afflicted with chronic infection of the sinuses, tonsils, or adenoids, which are apt to harbor the streptococcus or pneumococcus. Since so many of these children are hospitalized, they are naturally exposed, perhaps more than usual, to pathogenic organisms. Because of a low colloidal osmotic pressure of their blood, there is an abnormal tendency for filtration from the blood into the peritoneal cavity, thereby, perhaps favoring the entrance of organisms into the peritoneal cavity. Moreover, since ascitic fluid is such a good culture medium, this would likewise encourage infection.

In summarizing the data on pathogenesis, one is almost forced to the conclusion that the disease may be contracted in more than one manner. Of the three methods of transmission described, it would appear that the first and third are most common. The author is of the opinion that the disease is more often blood-borne, and in a large percentage of cases, the primary source is an upper respiratory infection. Certainly the occurrence of an upper respiratory infection is commonly noted to precede the peritoneal manifestations by a large number of observers. It is agreed by most observers (Pollock,[5] and others) that in a majority of instances the development of streptococcus peritonitis is dependent upon an antecedent infection of the respiratory tract. If such a means of transmission of infection is possible in streptococcus peritonitis, it seems logical to assume it may apply to many cases of pneumococcus peritonitis, particularly in the children with the history of upper respiratory infection.

Although routine vaginal smears were not made in the present series, a vaginitis was noted in only one instance; in this case the vaginitis developed while the patient was under observation and three or four days after the onset of the disease. Culture revealed a pneumococcus of the

same type as found in the peritoneal cavity. Certainly, transmission through the uterus and tubes is not the only mechanism, else the disease would not be observed in boys. Six of 20 cases reported by Barrington-Ward[6] were boys. In the author's series of 26 cases, 8 occurred in boys, although in 5 of these boys a nephrosis was present before the disease developed.

There are other possible avenues of transmission, such as spread by way of the lymphatics through the diaphragm, but they do not seem as important as the three mentioned.

PATHOLOGY

The first pathologic response is a hyperemia and edema of the intestine along with the deposition of a sticky, fibrinous exudate over the serosa of the intestine, omentum, etc. Enlargement of the mesenteric lymph nodes is commonly observed. Many authors have noted a hyperemia of the fallopian tubes in a large percentage of cases. After a day or two a thin, cloudy, yellowish-green exudate with numerous flakes of fibrin develops. This fluid may accumulate in huge quantities; at times two or three liters will be encountered at operation. Within three or four more days the fluid thickens, becoming true pus. It may then be quite homogenous (retaining a greenish tinge) but usually contains many large masses of fibrin. It is at this time, i.e., several days after the onset, that the "walling off" process becomes notable. Circumscribed abscesses may develop at any point in the peritoneal cavity. Although some authors have observed abscesses in the pelvis more frequently than at any other site, this is not true in the author's series. Perforation of the abdominal wall at the umbilicus tends to take place regardless of whether or not encapsulation of the pus has developed. In the author's series, perforation took place in 20 per cent of the cases (excluding the nephrosis group). Pneumonia and empyema represent the two most common complications, and when present, may be very important contributory factors toward death.

CLINICAL MANIFESTATIONS

The symptoms noted at the onset of the disease are extremely variable, particularly regarding severity of symptoms. Diffuse abdominal pain is almost always the first symptom complained of. It may be so severe as to completely disable the child in a few hours, or it may be so mild that the child will be up and about for two or three days before becoming bed fast. Vomiting is a constant and early manifestation, except in the mild cases. As a rule the vomiting occurs more frequently than in other types of peritoneal irritation such as appendicitis. Fever is noted early in the disease and may be present before much tenderness or muscle spasm of the abdomen develops. The abdominal pain is usually diffuse but occasionally starts in the right lower quadrant becoming diffuse a few

hours later. Tenderness is particularly apt to be diffuse. If the infection is an extremely fulminating one, diffuse and pronounced muscle spasm will be observed. Usually, the muscle rigidity is only mild; in fact in most instances the spasm is of a "doughy" nature. Distention usually does not occur until the third or fourth day of the disease.

Not infrequently, particularly if the disease is of several days' duration, the demonstration of dullness to the percussion note over the abdomen may be of considerable significance diagnostically, because of the rare occurrence of fluid in such diseases as appendicitis, etc.

A positive blood culture will be obtainable in roughly half the cases, but most commonly is not obtainable until the second or third day of the disease. The organism naturally is of the same type as that found in the peritoneal cavity. Type I and Group IV are most frequently observed, with the latter perhaps slightly more common than the former. Leucocytosis is quite constant and frequently is as high as 30,000 to 40,000.

For reasons previously stated, a large percentage of cases of pneumococcus peritonitis is observed in children with nephrosis. In the author's series, almost 40 per cent occurred in children with nephrosis; this, no doubt, is an unusually high percentage, but recent reports concerning pneumococcus peritonitis have emphasized the association of the two diseases. Streptococcus peritonitis was about as common, however, as pneumococcus peritonitis in this group of children with nephrosis. Tappan[7] reported 13 instances of pneumococcus peritonitis in 339 cases of nephrosis. When the infection is complicated by nephrosis, the mortality will usually be in the neighborhood of 60 per cent, which is 10 to 20 per cent higher than that encountered in pneumococcus peritonitis alone.

DIFFERENTIAL DIAGNOSIS

With a few exceptions, an accurate diagnosis should be possible if careful study of the case is made. It must be remembered, however, that the severity of onset of the disease is extremely variable. The disease with which pneumococcus peritonitis would be confused most often is acute appendicitis. In the former instance, fever is usually noted early in the disease; in patients with abdominal manifestations localized to the right lower quadrant, the fever is frequently so high as to be incompatible with acute appendicitis with equal abdominal manifestations. Vomiting is apt to be more pronounced in pneumococcus peritonitis than in acute appendicitis. The diffuse character of the tenderness and pain is not noted in acute appendicitis until peritonitis has developed. Occasionally, in pneumococcus peritonitis marked muscle spasm is present but usually the muscle spasm is relatively slight and consists of a "doughy" resistance. The history of an upper respiratory infection preceding the abdominal symptoms, or the presence of a vaginitis in girls, should lead one to suspect pneumococcus peritonitis and not ap-

pendicitis. The demonstration of fluid in the abdominal cavity, in children previously healthy, is another feature pointing strongly to the pneumococcus as the etiologic factor in the peritonitis.

Leucocytosis, on the average, is higher in pneumococcus peritonitis than in lesions such as appendicitis, Meckel's diverticulum, etc. The Hippocratic facies which is so constantly observed in peritonitis due to the *Bacillus coli* is rarely present in pneumococcus peritonitis, and, when it is present, is noted usually only in the terminal stage.

If acute abdominal symptoms develop in a child with a preexisting nephrosis, pneumococcus peritonitis should receive early diagnostic consideration because of the frequency of this association.

The most difficulty in differential diagnosis is usually experienced in discriminating streptococcus from pneumococcus peritonitis. The onset and clinical findings may be quite similar. The majority of cases of streptococcus peritonitis are usually noted in infants; in this disease there is not such a predilection to affect female children. A positive differentiation may be possible only by examination of material obtained by abdominal puncture.

There is considerable dispute about the safety of diagnostic puncture, but definite and proved instances of damage produced by this procedure are lacking. It is, in reality, simply performed, and may yield a positive diagnosis. The skin is treated with iodine and alcohol, a small wheal is made with novocaine, and a tiny slit is made in the skin with a knife. A dull needle with a large bore (e.g., spinal puncture needle) is inserted into the peritoneal cavity and an attempt is made to aspirate. Obviously a quantity as small as a portion of a drop is sufficient to make a smear and gram stain. If short-chained streptococci are the cause of the peritonitis, difficulty may be experienced in differentiating them from pneumococci; positive identification may not be possible until results of culture are known twenty-four hours later. If numerous kinds of organisms, with a predominance of gram-negative bacilli (*B. coli*) are found, the peritonitis may be considered to be of appendiceal origin.

Blood culture is another reliable method of making a positive diagnosis, but is positive in only about half the cases. Moreover, at least twenty-four hours must elapse before the results are known.

TREATMENT

As stated previously, there is considerable difference of opinion regarding the advocacy of operation in the primary stage of the disease. Mortality statistics on operated and nonoperated cases are bound to be misleading, because many of the patients will be so ill that operation will not be considered. This situation would tend to show a comparatively higher mortality in the nonoperated cases than in the operated cases, but would not be an accurate estimation of the value of

operation. As a matter of fact, the statistics* in the series herein reported favor postponement of operation. Of the four patients upon whom operation was performed in the acute stage, two died, a mortality of 50 per cent. Of the remaining 12 (5 of whom were operated upon later for encapsulated abscess), only 5 died, or a mortality of slightly less than 42 per cent. The author is, therefore, of the opinion that operation should be performed only after encapsulation of pus has taken place.

It is a very significant fact that if the child survives the first few days, he is apt to recover. Of the patients in our series who were operated upon for an encapsulated abscess, none died. Apparently, the formation of an abscess is indicative of the development of considerable active immunity.

There is a general agreement among the various observers that antipneumococcus serum should be given as in other pneumococcus infections (e.g., pneumonia, etc.). However, there are not many favorable reports in the literature regarding its use. It was used on 7 cases in the series herein discussed, but only in 2 instances was there a definite favorable effect. One patient sustaining a favorable effect was a child with nephrosis; in this instance the effect was so definite as to lead one to believe it may have been the responsible factor in her recovery.

In one of the patients with pneumococcus peritonitis, a girl aged eleven years, in whom a Type I organism was isolated, the titer of her serum for the pneumococcus six weeks after onset of symptoms was higher than the titer of the commercial antipneumococcus serum. Obviously if the titer of the patient's serum approaches that of the commercial serum, its injection could not be expected to have any significant beneficial results.

Other supportive measures including subcutaneous saline and intravenous glucose are usually indicated to maintain water balance and to supply at least a small amount of calories. Transfusions appear to be unusually helpful and should be given to all patients who are seriously ill. During the acute stage of the disease, no food or fluid should be given by mouth.

All of these children must be observed for many weeks, particularly for the development of an intraabdominal abscess. When an abscess forms, it should be drained surgically. It is especially necessary to observe the patients for many weeks even though recovery seems to have taken place, because abscesses have been known to form weeks after the patient was apparently well.

SUMMARY

A study of the cases of pneumococcus peritonitis (26 in number) occurring in the St. Louis Children's Hospital during the past eighteen

*These figures exclude the cases with nephrosis, since none of them were operated upon.

years, has led to certain deductions. In this series, it appears that development of peritonitis secondary to infections, such as those of the upper respiratory tract, is more common than any other mechanism in pathogenesis. The author is of the opinion that the correct diagnosis can usually be made in differentiation from acute appendicitis, by noting such features as early development of fever, profuse vomiting, diffuse character of tenderness and pain, prevalence in girls. Diagnostic puncture of the abdomen is justifiable in children when diagnosis is uncertain, and rarely fails to aid in the establishment of a correct diagnosis if the peritonitis is of pneumococcal origin. For many reasons immediate operation appears to be contraindicated. Although the present series is far too small to allow conclusions regarding this point, the results favor waiting until a localized abscess forms.

It is a striking fact that if the child survives the acute stage of the disease, recovery is almost certain, even though one or more localized abscesses form, provided, of course, such abscesses are properly drained.

Pneumococcus peritonitis is a common complication of nephrosis. The mortality in these children will be higher than in previously healthy children. In this series it was 54 per cent contrasted to 44 per cent in the previously healthy children.

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THE DISAPPEARANCE OF GALLSTONE SHADOWS FOLLOWING THE PROLONGED ADMINISTRATION OF BILE SALTS

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A REVIEW of the end-results of gallbladder surgery seems to indicate that removal of the gallbladder and stones is not the entire answer to this problem. Judd,[1] in analyzing the results of cholecystectomy upon the basis of pathologic changes in the gallbladder, found that when these changes were minimal, the results were satisfactory in 64 per cent of the cases, and when cholecystitis and stones were present, they were satisfactory in 87.8 per cent. In cases of noncalculous cholecystitis, however, Graham and Mackey[2] reported satisfactory results in only 30 per cent of the cases, and improvement in another 30 per cent in which cholecystectomy had been performed.

It is evident from these reports, as well as from the results of other investigators, that only in the presence of severe symptoms (such as colic) associated with gallstones will removal of the gallbladder give satisfactory results in a large percentage of cases. Even in many of these cases, subsequent investigation will reveal that although these patients are entirely relieved of colic, they continue to suffer from indigestion, food intolerance, and constipation. These results become intelligible when one considers the fact that symptoms in cholecystitis are due to three factors, such as: (1) Infection of the gallbladder; (2) mechanical effects of stones; and (3) disturbances in the bile salt metabolism, which result in indigestion, disturbances in the digestion of fat, and constipation. Cholecystectomy and removal of the stones correct the first two factors, but do nothing about the third. Consequently, there are residual symptoms following cholecystectomy.

A fact established early in the history of bile physiology was the circulation of the bile acids, a rapid adsorption of the bile salts from the intestine with prompt reappearance in the bile. Greene, Aldrich, and Rowntree[3] confirmed the enterohepatic circulation of bile acids by showing their presence in the portal blood after oral administration. Bile salt excretion is uniform during the day in spite of a single daily feeding (Smith, Groth, and Whipple).[4] Daily refeeding of all bile secreted from a fistula raises the bile secretion, but when high levels are attained, the output falls behind the intake. This also occurs when a bile surplus is produced within the body. The disappearance of the surplus and its fate remain a mystery (Smith and Whipple).[5] The normal daily output of bile salts can be increased by a meat and fish diet and decreased more by a carbohydrate than a fasting diet. This

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suggests an exogenous factor influencing bile acid production. An interesting parallel between urinary nitrogen and the bile salt secretion apparently points to an important endogenous factor, probably concerned with body protein metabolism (Whipple).[6]

It is generally thought that the bile acids are produced by the liver parenchyma, since a slight injury to the liver by chloroform will cause a great drop in bile salt output which returns to normal with the rapid

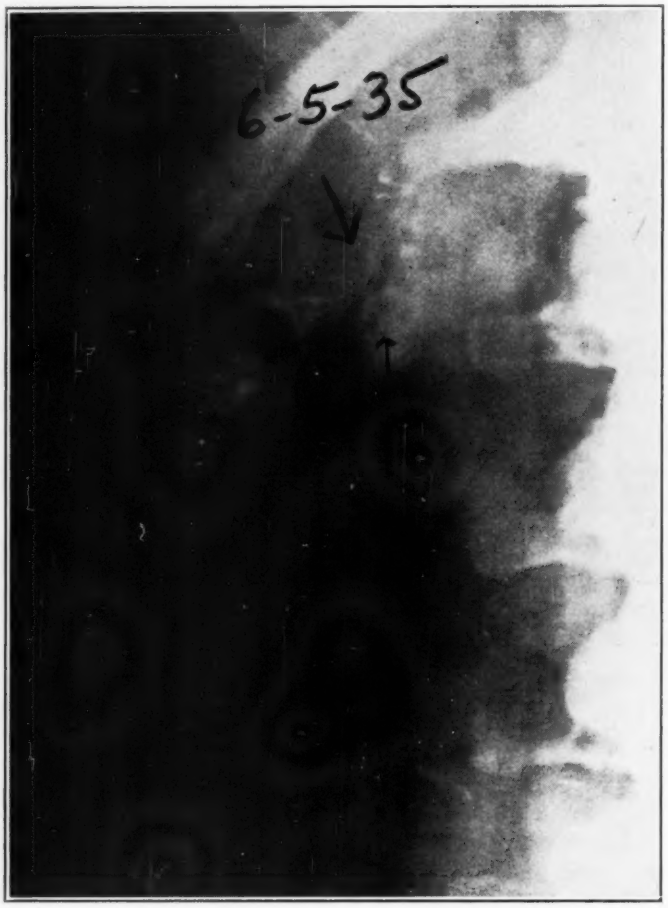

Fig. 1.—Numerous round negative shadows are present in a poorly functioning gallbladder.

repair of the liver cells. Protease intoxication causes a considerable increase in the breakdown of body proteins, and a fall in the output of bile salts. This may be due to the fact that the protease also causes an impairment of liver epithelium as it does to the secretory cells of the kidney. X-ray over the liver causes a fall in the bile salt output, but not as much as chloroform, protease, or large doses of phosphorus. Infection in other parts of the body and pregnancy also reduce the output of bile salts.

The employment of bile salts in the treatment of liver and gallbladder disease has been regarded as a logical and valuable approach to these cases. In a theoretical consideration of the metabolism and function of bile salts, one finds many factors which support the rationale of their use in the medical management of gallbladder disease.

The functions of bilt salts when they reach the intestine are well known. They aid in the digestion and adsorption of fats; they have

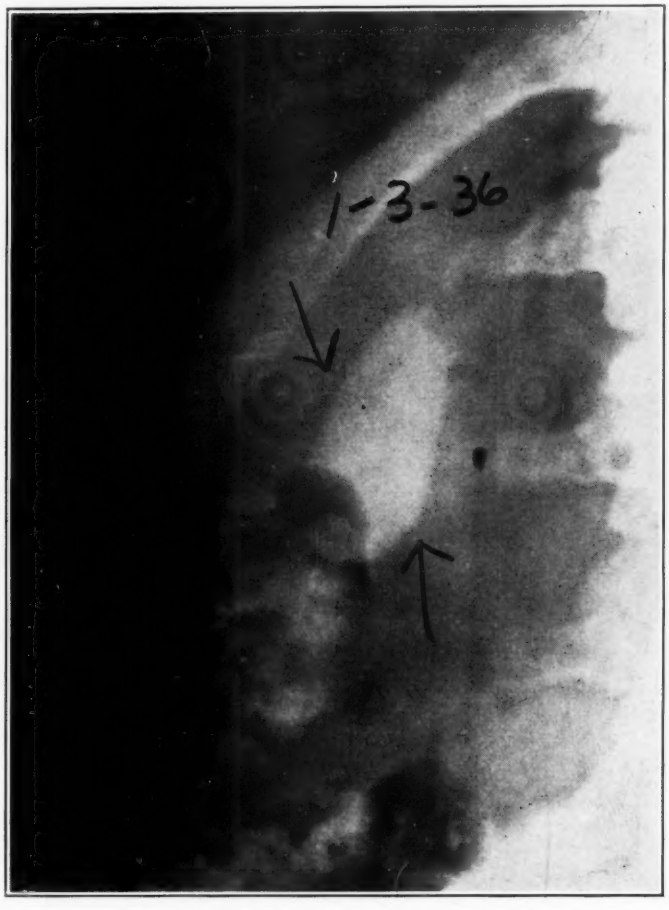

Fig. 2.—Same case 6 months later, after the oral administration of bile salts. Normally functioning gallbladder with no negative shadows present.

been known to stimulate the flow of pancreatic enzymes; and they seem to have a tonic effect on intestinal motility.

Another important rôle ascribed to the bile acids by both Wright and Whipple,[7] and Andrews and his coworkers is the relation of the bile acids to the metabolism of cholesterol. The recent work of Schoenheimer and Hrdina, 1931,[8] and Andrews, Schoenheimer, and Hrdina,[9] (1931a, b, 1931) is significant. They showed that most of the cholesterol of human bile is present in the form of water-soluble complexes with the bile salts.

These complexes are so unstable that when they are subjected to dialysis, the bile salts pass out, and the cholesterol is precipitated. Therefore, it would appear that any disturbance which lowers the ratio of bile salts to cholesterol could cause precipitation. Moreover, analysis showed that bile in cholelithiasis has a much lower bile salt-cholesterol ratio than the bile from bladders not containing stones. If this hypothesis is true, then cholesterol gallstones should disappear if the normal bile salt-cholesterol ratio is restored. The purpose of this investigation then is to study the effect of oral administration of bile salts upon cholesterol gallstones in vivo.

A series of known gallstone cases were used in this study. The stones were demonstrated by cholecystograms. These patients were fed three grains of bile salts three times daily. A teaspoonful of olive oil was likewise fed to furnish an adequate stimulus to empty the gallbladder. After a period of nine months, these patients were studied again. The results are given in Table I.

TABLE I

UNIVERSITY HOSPITAL NUMBER	SEX	CASE	AGE	FUNCTION	FIRST X-RAY	SECOND X-RAY
638961	F	1	38	Poor	Numerous negative shadows present.	Normally functioning gallbladder. No stones present.
637599	F	2	46	Fair	Numerous negative shadows present.	Normally functioning gallbladder. No stones present.
638826	F	3	33	Fair	Two large gallstones covered with a calcium capsule.	Gallstones unchanged.
626830	M	4	57	Poor	Two large stones. No dye entered gallbladder.	Gallstones unchanged. No dye entered gallbladder.
640889	F	5	49	Fair	Numerous negative shadows present.	Gallstones unchanged.

Subjectively these patients showed definite improvement. Their digestion was better, they complained of less gas or distention, and they could eat any food without distress. In fact, at the end of the course of treatment, four patients were symptom-free. The last patient, although materially better, continued to complain of discomfort in the upper right quadrant. During the early months of treatment of Case 2, the patient had frequent attacks of colic; as time passed, however, these attacks became less frequent until they disappeared entirely. In Case 1 the patient was symptom-free throughout the entire course of treatment.

A summary of the x-ray findings is of interest, in that in Cases 1 and 2 the gallstone shadows disappear entirely, and a normally functioning gallbladder was the end-result. In Case 4 the gallstones were un-

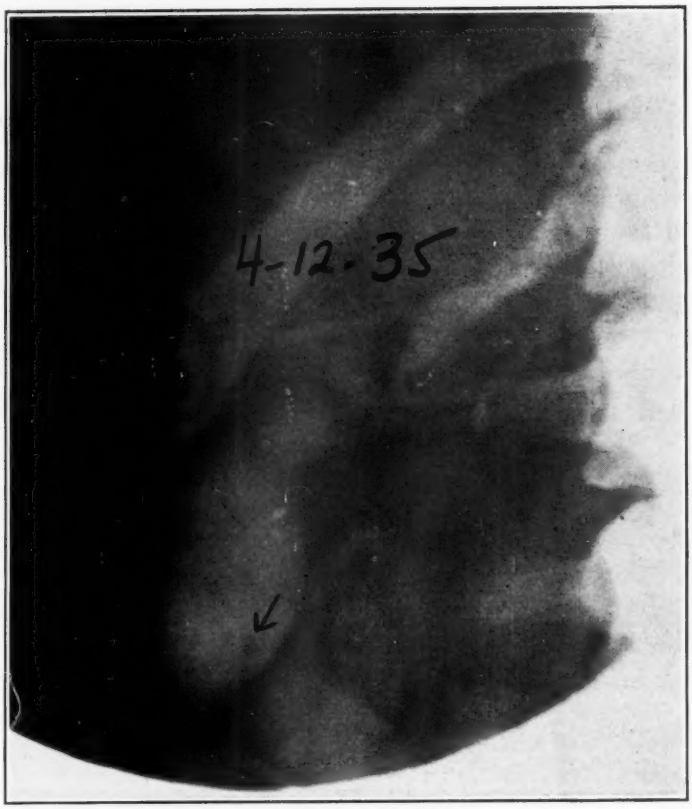

Fig. 3.—Numerous round negative shadows present in a moderately well functioning gallbladder.

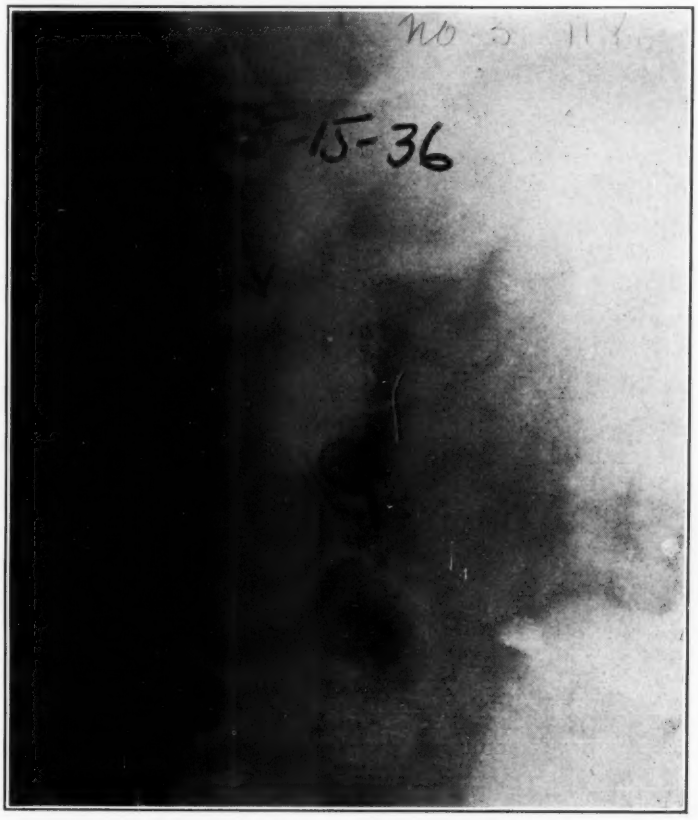

Fig. 4.—Same case 9 months later, after oral administration of bile salts.

changed after treatment. Failure in this case may be explained on the basis that the cystic duct might not be patent, consequently one could not hope for success.

The gallstones in Case 3 were covered with deposits of lime salts. Failure in this case becomes intelligible. There is no apparent explanation for failure in Case 5. Possibly the dose of bile salts was inadequate, and the treatment was not continued long enough.

COMMENT

Rosenak and Kohlstaet,[10] in 1936, and others have reported beneficial subjective effects resulting from the bile salt treatment of patients with diseased gallbladders. The most noted improvement was observed in the control of digestive symptoms and constipation. With their results in mind, bile salt therapy suggests itself as the logical way to treat those residual symptoms which follow cholecystectomy.

In the observations described above, it is believed that the disappearance of gallstones following treatment in Cases 1 and 2 is significant. In both these cases, the end-result was both subjective and objective cure, with a normally functioning gallbladder as the end-result. The possibilities of this method of treatment can be determined only by further study. These observations suggest that the cause of cholesterol gallstone formation is a bile salt deficiency; when remedied, the gallstones disappear.

CONCLUSIONS

1. In cases of cholecystitis and cholelithiasis, subjective relief is obtained by the oral administration of bile salts.

2. Gallstone shadows as demonstrated by x-ray may be made to disappear following prolonged administration of bile salts.

3. The cause of cholesterol gallstone formation is a bile salt deficiency resulting from liver damage.

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TREATMENT OF OSTEOMYELITIS OF THE CRANIAL VAULT

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TREATMENT of osteomyelitis of the cranial vault has been more or less of a hit-and-miss affair until the last few years so far as operative measures are concerned. The mortality rate was very high. The good results which have been obtained by surgeons who have boldly extirpated the full thickness of the skull well beyond the diseased area speak for themselves. They are so much better than those previously obtained. This mode of attack on the diseased bone was not advocated until about twenty-three years ago, and was not seriously carried out until during the last decade. Even now it is not generally appreciated. McKenzie advocated this procedure in his first famous contribution in 1913, and stated that "Once progressive osteomyelitis has set in, the only chance of saving the patient lies in immediate and entire removal of the diseased bone. We can scarcely hope to cure diffuse osteomyelitis by simple drainage, hence limited and partial measures, such as incisions, trephining, etc., are useless." It is remarkable how long it has taken this idea to permeate our own mentalities.

This discussion will consider only the *treatment* of, and surgical principles concerned with, the condition. Etiology, with the pathways of infection, pathology, bacteriology, symptomatology, and diagnosis, will not be dealt with in detail. All, or some, of these phases have been discussed in previous contributions by Adson,[1] Blair and Brown,[2] Bulson,[3, 4] Campbell,[5] Connor,[6] Dabney,[7] Eagleton,[8] Fincher,[9] Fleming,[10] Frey,[11] Furstenberg,[12] Gelanze,[13] Gerber,[14] Hanson,[15] Hastings,[16] Knapp,[19] Lillie,[20] Luc,[21] McKenzie,[23] Marek,[24] Mason,[25] Meyers,[26] Mosher,[27] Mosher and Judd,[28] Schilling,[30] Skillern,[31] Turner and Reynolds,[32] Wilensky,[33] Woodward,[34] and other writers. Some of these writers have given detailed and comprehensive review of the literature, while others have stated their own clinical observations and have given reports of cases. Mosher stated that four of the most noteworthy papers which have appeared in recent years on the subject have been those by McKenzie, Bulson, Wilensky, and Furstenberg. I would like to add his name to that list. Since these papers have covered the subject matter so completely, my purpose in presenting this paper resolves

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itself into two objectives: first, to emphasize and accentuate the importance of *complete* operation, and second, to give some clinical observations.

CONSIDERATION OF GROSS PATHOLOGY AND SURGICAL PRINCIPLES

Regardless of whether the initial infection enters a bone of the cranial vault by direct extension from one of the accessory nasal sinuses, the middle ear, or mastoid; by retrograde thrombosis of veins; by thrombophlebitis, retrograde thrombosis and extension through the dura, as suggested by Furstenberg; or by metastasis, the infection is first a local one in the bone, in the majority of cases, and so can be considered from a practical standpoint. Therefore, what could be more logical in combating this otherwise destructive condition than to attack it as early as the diagnosis can be made, and to remove completely the involved area with its source of infection? As was noted by McKenzie, osteomyelitis of the cranial vault very seldom metastasizes to other bones and other organs, in contrast to a similar infection of the long bones. Radical removal should therefore effect a cure. Once it has begun, however, its inevitable tendency is to spread to adjoining portions of the skull and, if untreated, it may run the entire gamut through extradural and subcutaneous abscesses, cortical and subcortical abscesses, thrombosis of major sinuses, generalized involvement of the skull, meningitis, suppurative leptomeningitis, and sepsis, to death.

It is well recognized by all writers that most cases of osteomyelitis of the frontal bone occur in young people and that the infection tends, for a certain period of time, to localize to one side, or at least be confined to one bone. It is believed that the fibrous tissue which exists between the suture lines before complete closure acts as a barrier to the extension of infection, and makes the disease more amenable to eradication.

It is also recognized that the condition frequently begins with stealthy and insidious onset, and that a gross pathologic process, which could and should be removed, exists before the radiographic films show the clear-cut undeniable moth-eaten picture of well-established osteomyelitis. F. W. Law and I have reviewed serial x-ray films of cases of osteomyelitis of the frontal bone. We were impressed with the early differences in the appearance of the two sides of the postero-anterior films. These differences are more apparent when the films are reviewed in reverse. If attention is focused on the region of the frontal bone where the eventual breaking down of bone occurs, one can observe an area of less density in earlier films. This is due to softening and partial decalcification of the area. Evidence of the presence of this area is very questionable in the earliest films, or it

may not exist at all. After a few days, however, a rounded area of less density is visible at the point where the eventual breaking down will occur. This area is probably more noticeable if viewed from a distance of five or six feet than at a short distance. In some instances in our experience, films were made at the time frontal sinusitis or orbital abscess was present and not again until a definite breaking down of the cranial tables with formation of a subcutaneous or an extradural abscess had occurred. The intervals between the x-ray examinations in many instances were surprisingly long. In view of these observations, we advise that a posteroanterior film be made at intervals of every two or three days with the expectation of finding the area of less density which gradually appears several days (about ten days to two weeks) before the typical moth-eaten picture makes its appearance. By so doing, the condition may be recognized, and operation carried out at an earlier date without so much sacrifice of bone. At least, evidence may be sufficient to warrant an exploratory drill hole at the site.

Although osteomyelitis of the skull may spontaneously occur without any instrumentation by the surgeon, it must be acknowledged that a large number of cases follow instrumentation or operation. This is especially true following any operation upon the sinus. It is believed that fewer cases would develop were the sinus operated upon with purely surgical principles in mind, leaving the question of cosmetic result for a later date. Full, open, and prolonged drainage with iodoform gauze packing after a proper operation would allow the sinus to fill up with firm granulation tissue, and completely obliterate the sinus. Future troubles might be avoided. The depressed scar can readily be removed by a minor plastic operation. Mosher holds this view, and Ross Faulkner in a recent conversation gave the same opinion.

PREOPERATIVE MEASURES

General Condition of Patient.—Some patients have already undergone a radical operation on the sinus or multiple operations for sinusitis, orbital abscesses, etc., and are frequently in a run-down and debilitated condition, with loss of weight and strength. As a result the hemoglobin may be low and resistance poor. One or more small transfusions before operation are advisable. At any rate, the patient should be typed and cross typed with a donor held ready for transfusion. In cases of severe spontaneous generalized osteomyelitis associated with pansinusitis, with the patient in a markedly septic condition, only preliminary trephining and aeration of the sinuses should be done. Should a large, extradural lake of pus be present, as evidenced by hemiparesis or hemiplegia, two or three trephine openings should be

made in the skull to allow escape of pus. These patients are in poor condition at best, and will not withstand successfully massive, radical resection of the skull.

Ventriculograms.—Should the presence of a brain abscess be strongly suspected, but without marked localizing signs and symptoms, preliminary ventriculograms are indicated. Should an abscess exist in the frontal lobe, ventriculograms will definitely establish the location of the lesion. This method is preferable to an exploratory puncture through an infected dura after the bone has been removed, and it can be done with a reasonable degree of safety before the radical procedure. Ventriculograms are preferred to encephalograms. Localized meningitis might be spread in making the latter.

It is advisable to drain a brain abscess if it can be located at the time of resection of skull, rather than at a later date. The exposure is all one could desire for drainage of the abscess. Should an underlying abscess be present, and not drained at the time of the radical operation on the bone, there is danger of rupture into the ventricle or meninges during the interval of waiting. It is reasonable to assume that the underlying brain is edematous in all cases of osteomyelitis with an extradural pocket of pus, associated with headache and other symptoms of brain abscess. Thus, one may not recognize the presence of an abscess.

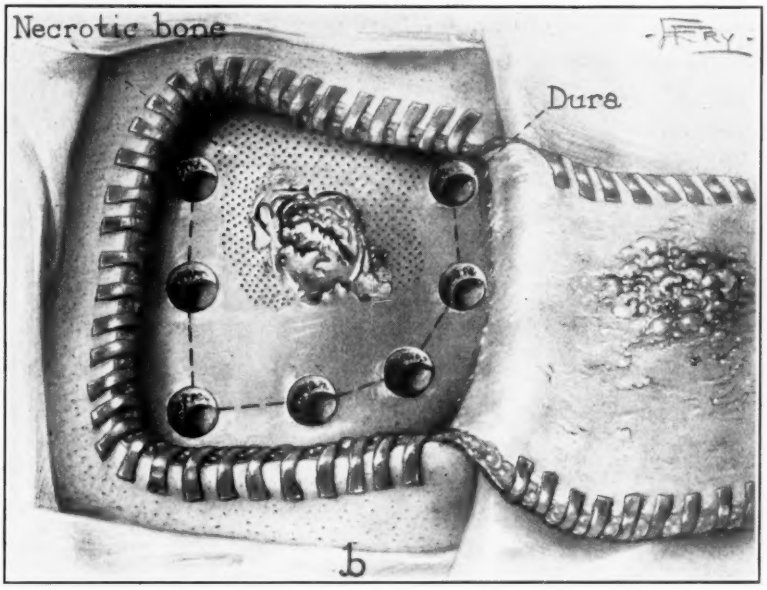
From the ventriculograms one could make the diagnosis, and localize it or prove its absence. The intracranial symptoms may be due only to edema or localized serous meningitis. A hazardous exploratory puncture through the infected dura would then be obviated. I probably lost two patients due to the fact that preliminary ventriculography was not carried out.

PRINCIPLE POINTS IN THE OPERATIVE PROCEDURE

Anesthesia.—I have found that the best anesthesia is a combination of avertin and regional. Avertin reduces blood pressure and lessens the tendency to bleed. In most suppurative conditions, local anesthesia is contraindicated. In this operation, however, as in brain abscess, it is very efficacious. Bleeding is lessened due to the admixture of suprarenin with the novocain. The anesthetic effect lasts for at least two hours. Should there be restlessness and moving of the head, a small amount of ether is advisable. A postnasal plug is used in all cases of osteomyelitis of the frontal bone.

Incisions.—When the disease is localized to one side of the frontal bone, the following incision is advised. Beginning at a point beyond the outer canthus, the incision is carried inward just above, and not through, the eyebrow to a point just above the inner canthus; for a short distance obliquely upward and inward, about one-half inch be-

yond the midline over the root of the nose; upward and backward for a distance of one inch or more beyond the edema of the scalp; downward and outward into the temporal region (Fig. 1*a*). When this flap, consisting of all soft parts, including the periosteum, is reflected, adequate exposure is afforded. Should it be necessary to



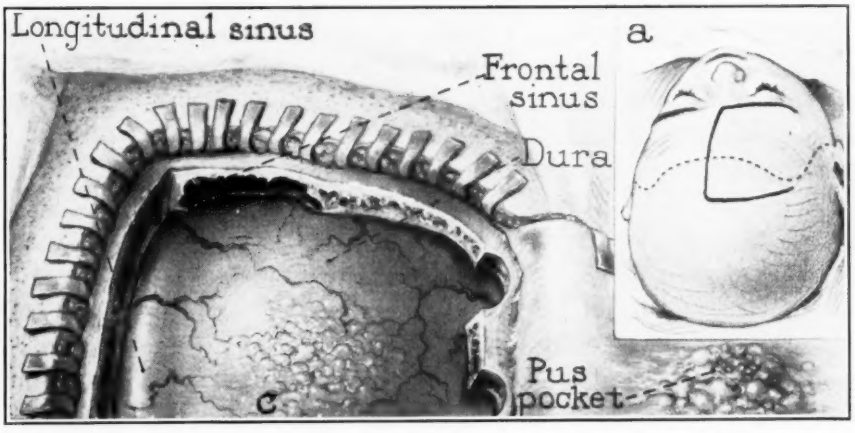


Fig. 1.—Illustration of operation for osteomyelitis of the right side of frontal bone. *a*. Incision. *b*. Bleeding from scalp controlled by skin clips. Area of bony removal outlined by drill holes. Shows broken-down area in bone with overlying periosteal abscess. *c*. Shows complete removal of bone, heaped-up granulations at site of extradural abscess, and frontal sinus, with part of posterior plate removed, left wide open.

exenterate the ethmoids, the incision at the inner canthus can easily be extended down along the nose. In the event a Lynch operation has previously been done, the first line of incision follows the old scar beneath the eyebrow instead of above it, to avoid having two scars.

Should the disease involve both sides of the frontal bone, I prefer making a similar flap on the opposite side rather than the inverted T-shaped incision. Better exposure can be obtained, the upper or posterior margin of the bone defect will not be covered with scalp, and scarring will not be increased, for the reason that the upper limbs of the incisions are well within the hairline. If the disease is generalized, two large bilateral anterior scalp flaps are made simultaneously so that the anterior portion of the skull can be removed. The incisions are similar to that for an osteoplastic flap. Later, similar posterior flaps should be made with removal of the posterior part of the skull. This requires two or three stages.

Control of Bleeding.—In these cases, the scalp bleeds very vigorously, and it is imperative to control bleeding throughout. The procedure necessarily requires considerable time and some loss of blood, in any case, during removal of the bone. The initial loss of a small amount of blood does not affect the patient, but continuous loss weakens the patient to such an extent that the surgeon may have to discontinue the operation, or finish it in a hasty and inconclusive manner. Therefore, systematic control of bleeding is highly essential from the beginning of the operation.

When the incision is made, it is carried down at the particular point to the outer table of the skull for one inch or one and a half inches at a time. The scalp edges are reflected, and skin clips are applied to the cut edges on both sides of the incision and are closed snugly. This manner of controlling bleeding from the scalp is consistently carried out step by step until the complete incision is made (Fig. 1*b*). When the flap is reflected, major bleeding points from the under surface are touched with the coagulating electrode, and the scalp flap is wrapped in gauze. Some oozing will take place, especially from the limb of the incision over the supraorbital ridge. Angulated, self-retaining retractors inserted at this point will control the oozing. In removal of the bone, should retention of it as one piece not be desired, the upper or posterior portion of the area should be first attacked by removal of the entire thickness of the skull between drill holes in healthy bone (Fig. 1*b*). The full extent of bone extirpation should be decided upon and carried out at a given point, and the margin of the bone covered with iodoform gauze. Pressure by an assistant for a short time will control bleeding from the bone margin at a given point. Bone wax should not be used on the skull margins which are to remain, for the reason that it will act as a foreign body and may be a source of infection after the incision has healed.

Systematic removal of bone about the periphery should be continued and the bone edges covered with iodoform gauze in the manner described. By this method all bleeding will be controlled except the

continuous oozing which takes place from the dura, and during the obliteration of the frontal sinus. After removal of the mucous membrane extending into the opening of the nasofrontal duct, iodoform gauze is packed firmly into the remaining portion of the sinus and left. Bleeding in this region will then cease. By leaving the central necrotic portion of bone as the last to be removed, bleeding from the dura can thus be lessened.

Regardless of what one may do there is a certain loss of blood. We have routinely followed each operation with a blood transfusion.

Amount of Bone Removal.—All writers who advocate resection of the skull state that a sufficient amount should be extirpated to insure complete removal of the diseased bone. This has been especially emphasized by McKenzie, Bulson, Furstenberg, Adson, Wilensky, and Mosher. Furstenberg begins in the grossly infected and broken-down area and extends his bone removal as far as he considers it necessary.

I agree with Mosher who states: "The edema of the skin of the forehead is a rough guide to the extent of the bone and the periosteal infection. Further . . . if there is actual bone necrosis, the bone is infected without necrosis for 1 to 1½" beyond the necrotic area." To substantiate his opinion, he removed bone at varying distances from the actual necrotic portion, and sectioned them. He was able to see the changes in the bone from the diseased to the healthy bone structure. Furstenberg states: "Both outer and inner plates are removed, and the resection is carried well beyond the obvious limits of the disease. For reasons already described it often seems feasible to limit the resection of the cranial bones to a suture line."

When a trephine opening is made at a given position, should droplets of pus exude from the diploe, it is obvious that the drill must be set farther back in order to insure complete removal. The bone may be removed in one piece or piecemeal (Fig. 1*c*). I have done both. It seems to make little difference which method is used. The former is quicker and leaves a well-shaped portion of bone for reinsertion at a later date, should this be desired. At times I have found the dura quite adherent at certain areas, and have felt that removal in one piece would jeopardize the integrity of the dura. At all odds, the dura should not be unintentionally opened.

The frontal sinus, or both sinuses, if they are diseased, should be widely opened, and the ethmoids exenterated, if deemed advisable. I agree with Mosher that the full external limit of the frontal sinuses should be exposed and removed if necessary to allow complete obliteration of the sinus. It has likewise been observed that this is a "danger spot" and may be the source of recurrence. It has been noted also that a portion of the anterior plate forming the supraorbital ridge can

be retained, and thereby diminish the deformity. The posterior plate should be removed low. If this is done, the entire cavity will be more quickly and completely obliterated with granulation tissue.

Closure.—If an opening in the dura leading into a cortical or subcortical abscess is found, and complete removal of diseased bone has been accomplished, the dura should be opened. Otherwise, exploratory punctures through the infected dura are inadvisable. If an abscess is drained, the scalp flap is sutured on itself, as described in a previous paper,[17] to permit proper dressing of the abscess. If none is found, all loose pieces of bone are removed from the surface lest they act as a source of reinfection. The strips of iodoform gauze which were placed along the bone margin and in the remnant of the frontal sinus are left in position. The dura and the operative field are washed off with azochloramid solution, pieces of gauze flats wet in the same solution are laid on the dura within the bone defect to the level of the outer table of the skull, with a rubber instillation tube placed between the pieces of gauze. The scalp flap is then returned to its position overlying the gauze packings, and it is loosely sutured with bridge sutures to the scalp margin about the defect, leaving the margins about one-fourth of an inch apart. These sutures prevent shrinkage and contraction of the flap. The skin clips which were placed on the scalp margins to control bleeding are left in position. Otherwise, bleeding from the scalp edges would be marked. The clips are not removed until the fourth day, at which time practically no bleeding occurs. I have never swabbed off the dura and bone edges with tincture of iodine as advocated by Adson, but I see no objection to it. No drainage tubes are necessary in that the area is wide open.

Both eyes and ears are well covered with vaseline gauze. A copious gauze dressing wet in azochloramid solution is applied and loosely fixed with a wet bandage and strips of adhesive, including the lower jaw, to prevent removal or slipping of the dressing. If a tight dressing is applied, compression of the brain through the bone defect will occur.

Postoperative Treatment.—Fluids are given very freely. If the patient becomes irritable due to increasing intracranial pressure, this can be lessened by administration of hypertonic sugar solution, copious bowel movements, and lumbar puncture, if necessary.

The first dressing is done on the second day, and all the dressing down to the flap is removed and renewed. It is well to protect the scalp with a mixture of zinc oxide and olive oil to prevent irritation by the solution. Instillation of azochloramid is done through the tube every two hours. This keeps the wound clean. No actual pus has been observed.

On the sixth day, under avertin anesthesia, the original gauze packings beneath the flap and against the dura are removed (Fig. 5*A*).

Peroxide is invaluable in loosening the very adherent gauze from the dura and in allowing slow removal of gauze without tearing the dura. The iodoform gauze packing in the remnant of the frontal sinus is removed and renewed. Similar pieces of gauze are placed on the dura, the flap is returned to its position, and dressing applied. It is not necessary to resuture the flap at this time. It will not shrink after six days. By the tenth day, the edges of the bone which have been in apposition to gauze will have become covered with healthy granulations. Under avertin anesthesia the gauze between the flap and the dura (Fig. 5*B*) is removed, and the scalp flap is loosely sutured in position, gapping well between sutures. Into these gaps, small pieces of iodoform gauze are packed. After three days, the scalp flap will have become adherent to the dura. Sutures are removed, leaving the two scalp margins separated one-fourth to one-half inch. This assures adequate drainage for the cut margins of the bone and successfully mitigates against reinfection of the bone edges. The troughlike gapping incision is loosely filled with iodoform gauze strips which are renewed daily or every other day until the wound has completely healed (Figs. 6*A* and *B*). The lower inner angle of the flap is left open so that prolonged packing of the dimplelike remnant of the frontal sinus can be done. It is most important that the sinus be completely obliterated with firm granulation tissue, otherwise reinfection would most likely occur. Mosher also emphasizes this point.

Plastic Procedure.—It is advisable to wait for six months or probably a year before the plastic procedure is performed. During this time, should a small subcutaneous pus pocket develop about a bone fragment which has not been removed, it can be opened and drained without interfering with the final cosmetic result. Furthermore, latent infection will not be stirred up at the time of the plastic procedure. It is remarkable how little scarring there is in some cases, even without a plastic procedure. The scalp becomes softened during the interval of waiting, and after the scar has been excised, the scalp edges can be easily approximated without tension and danger of infection and sloughing. It will be observed that the vertical scar has been drawn over to or beyond the midline, although the incision was made one-half inch beyond. The cosmetic result is good. The only noticeable part of the scar is from the inner canthus of the eye to the hairline. This portion may be obscured by vertical wrinkles. The scar resulting from the other two limbs of the incision is concealed in the hairline and above the eyebrow.

The average stay in the hospital for the last three cases of osteomyelitis of the frontal bone was forty-four days.

The general principles given above are followed in cases of osteomyelitis involving other bones of the cranial vault. Should it appear

that I have gone too much into details, I have done this for two purposes. First, with the hope that my experience may be of some benefit to others who have been combating this disease, and second, with the intention of "spreading the gospel" which has been so ably propounded by other writers, especially Furstenberg and Mosher.

REGENERATION OF BONE

McKenzie, in 1927, noted that "the defect in the frontal bone will subsequently be made good by new bone formation and this repair takes place rapidly." He did not state the length of time required. There are numerous other brief references to bone repair, but the first full discussion of the subject that I am able to find is by Furstenberg in 1931. He stated that the dura under favorable conditions is an exceedingly active regenerative tissue, in addition to the periosteum. His eight cases which survived were cured. The defects in the skull, which ranged in size from small defects to one including the cranial vault, were all completely closed "at the end of a period exceeding two years." This is sufficient evidence to disprove the arguments of those who have the "defect bugaboo."

Regarding the manner in which regeneration takes place, he states: "The regenerated bone has for its origin a connective tissue groundwork. The fragments and shreds of traumatized periosteum remaining within the wound become thickened and congested, and assume the appearance of granulation tissue. The latter serves as a young connective tissue base of an embryonic character in which ossification may follow. There is a rapid multiplication of connective tissue elements with a differentiation of some of the cells into osteoblasts. Thus there is formed an interlacing framework of trabeculae which is at first uncalcified, and is spoken of as osteoid tissue. The latter soon is infiltrated with calcium salts and there are formed numerous trabeculae or spicules of bone, completing the process of ossification."

After the operations done by him and the others of us who advocate wide skull resection, the periosteum and dura, which are the two main bone-forming tissues, are approximated. Both dura and periosteum are preserved. Regeneration should and does take place.

At the time of débridement of a compound fracture of the skull with loss of brain substance, both the dura and the periosteum may have been sacrificed to a considerable degree. In the instances where both dura and periosteum were removed, the degree of regeneration, if any, was slight. Cranioplasty[18] was necessary for closure of these defects. Likewise, in a smaller number of cases of brain abscess in which the dura is deliberately removed, yet the *periosteum* is preserved for the

most part, there is but little tendency for the defect to decrease in size. This statement is made after several years of personal observation of these defects. The facts substantiate to a degree the assumption of osteogenetic power or function of the dura made by Furstenberg.

In several recent cases of osteomyelitis in which the skull was generously resected, I have observed that regeneration is taking place at a surprisingly rapid rate (Fig. 2). In one case, it is complete. This has occurred without any outside aid other than good food and hygiene. Furstenberg emphasizes the unquestionable value of infrared light, but this light has not been used.

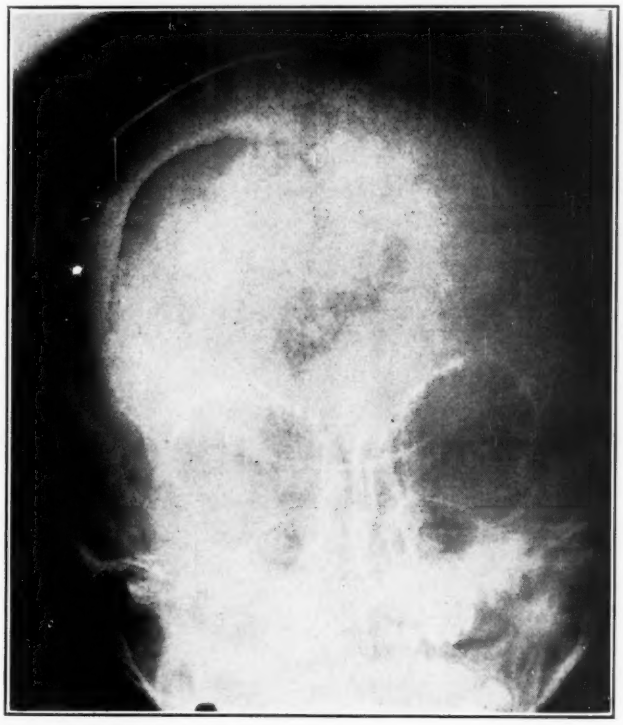
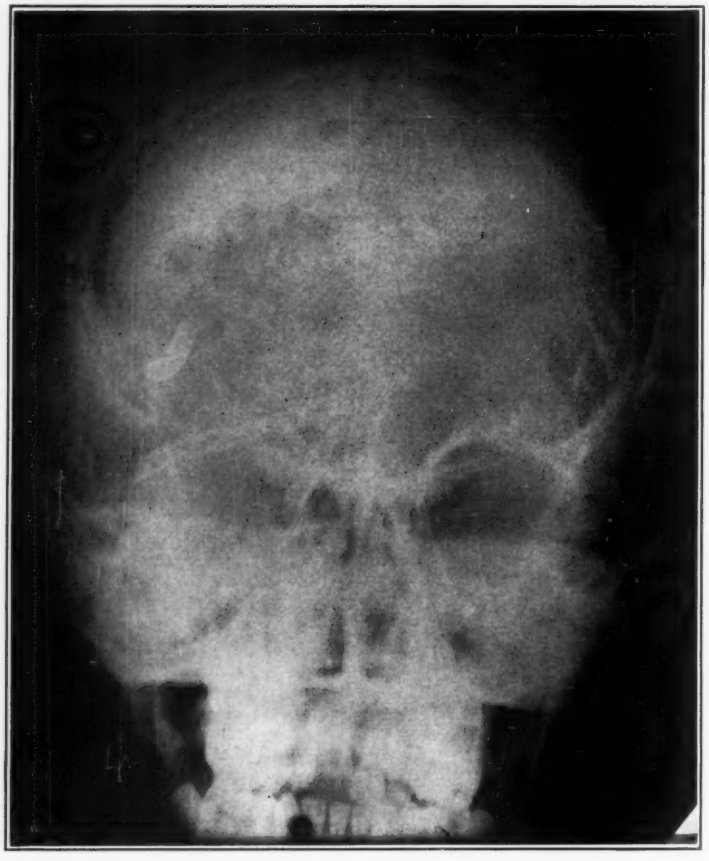


Fig. 2.—X-ray film showing amount of bone regeneration twenty months after radical resection of right half of frontal bone.

Naffziger,[29] in a recent article, advocated removal and preservation of the bone in an osteoplastic flap in certain cases of tumor. He replaced the bone either with or without boiling, following removal of the tumor. Several years ago, Dorothy Klenke, an associate on our neurosurgical service at Bellevue Hospital, removed the bone from a flap, in the belief that the underlying tumor was irremovable. The bone was sent to the laboratory. Several days later a second-stage operation was performed, and a benign tumor was removed. She sent to the laboratory, retrieved the bony portion of the flap, had it boiled, and replaced it in the defect. The wound healed by first intention.

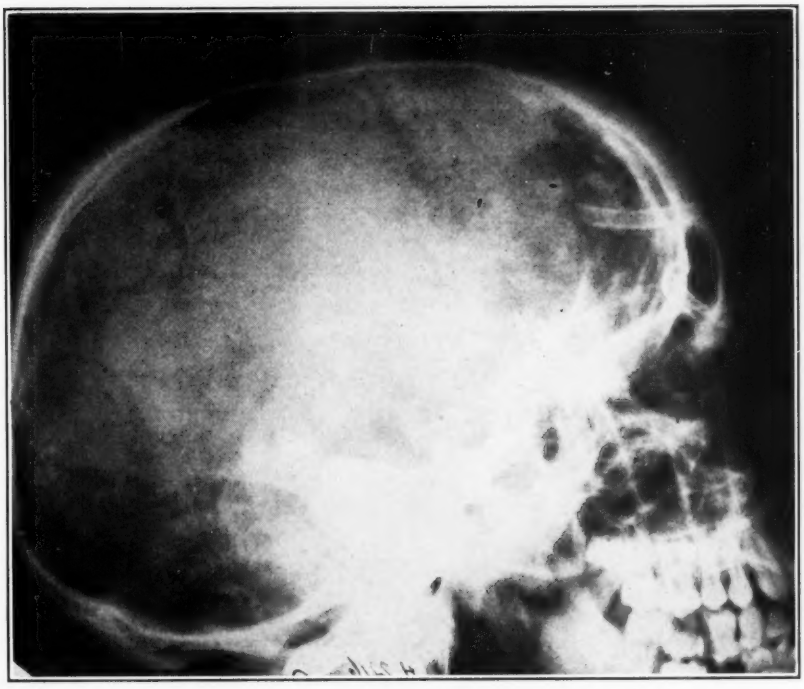
Naffziger stated that "in selected cases of osteomyelitis, particularly of the postoperative type herein mentioned, such procedures have given a new direction to the surgical problem." The case which he reported was one in which the wound became infected following an osteoplastic flap for the removal of a pituitary adenoma. He did not make reference to a case of true osteomyelitis such as is considered in this paper.



A.

Fig. 3.—Patient S. P. *A.* A. P. x-ray film showing extensive osteomyelitis of frontal bone September 3, 1935. *B.* Lateral view of x-ray film. *C.* Photograph of patient on same date.

On July 2, 1935, before becoming acquainted with the work of Naffziger, I removed a bloc of infected bone three inches by four inches from the left temporoparietooccipital region in a case of metastatic osteomyelitis secondary to a lung abscess. I expected to reinsert the piece of bone after twelve months had elapsed. Unfortunately the disease extended back into the occipital bone and across the midline into the opposite parietal bone, necessitating several subsequent resec-



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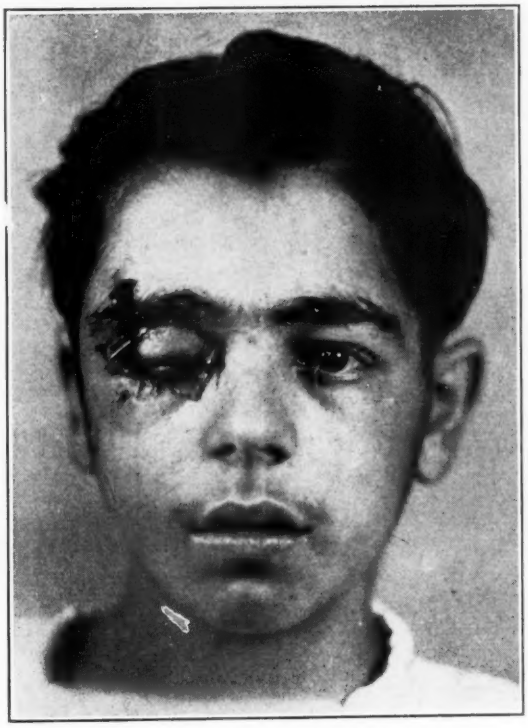


C.

tions by my associate, Wilfrid D. Wingebach. Meanwhile, regeneration of bone in the defect from which the first large piece of bone was removed has taken place to such an extent that implantation of the bone will probably not be necessary.

This method, which Naffziger proposed for the closure of a large defect, might be utilized in cases of massive resection of the skull for generalized or extensive metastatic osteomyelitis. Since regeneration of the skull is so complete, according to Furstenberg, it is questionable if any attempt at closure should be done.

I shall give a fairly complete report of one typical case with illustrations of the operation, and prints of x-ray films showing the progress of a given case. The recovered cases show great similarity. Detailed reports of all the cases will be made in another paper.

Infection following swimming. Suppurative ethmoiditis and sinusitis. Ethmoidal perforation. Orbital abscess drainage. Osteomyelitis of frontal bone. Massive skull resection with obliteration of sinus. Recovery.

S. P., fifteen-year-old schoolboy, was admitted to Manhattan Eye, Ear, and Throat Hospital to the service of Dr. David Jones on August 5, 1935, and was attended by Dr. Knopf. (Hospital No. 284396.)

History and physical examination showed that the patient went swimming one week before admission, and two days later developed pain, redness, and swelling over both eyes. The condition became steadily worse. On August 4, a swelling appeared behind the angle of the lower jaw on the right. On admission, there was marked redness, swelling, and tenderness of the upper and lower lids of both eyes with chemosis, much more marked on the right. There was enophthalmos with proptosis on right, but none on left. The right eye was fixed, while the left moved somewhat and there was photophobia in both. Ear examination was negative. Congestion of middle turbinates with creamy yellow pus from right and none from left was noted. Swelling the size of hen egg showed behind angle of right jaw. There was no induration or suppuration, and glands were palpable. The general examination was negative, and the patient was mentally alert.

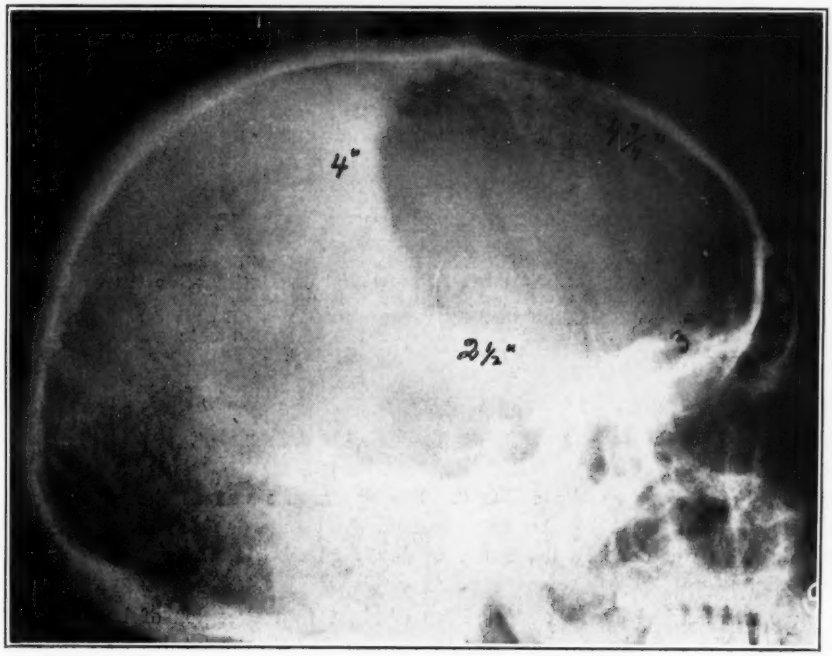
Examination gave an impression of acute frontal ethmoiditis, right, with possible early cavernous sinus thrombosis. Temperature, 103.6°; pulse, 100; respirations, 24. W.B.C., 21,500; polymorphonuclears, 82; lymphocytes, 18. Blood culture, negative.

X-ray examination showed involvement of all sinuses, most marked of ethmoids, more on the right than on the left. Frontal sinuses were of average size. The ophthalmologic report showed vision O.D. 20.20; O.S. 20.20. There was marked boggy edema of the right upper lid and the region above the right orbit; maximum tenderness at the upper outer segment of rim of orbit; marked chemosis of conjunctivae with moderate proptosis of globe, and very little mobility of globe. The cornea was clear, the pupil moderately dilated, and the iris and lens negative. Satisfactory examination of fundus did not reveal any gross pathology. Diagnosis: Orbital abscess.

On the same day an incision was made along right supraorbital ridge; the periosteum was opened with release of moderate amount of pus. A counter parallel incision was made halfway down the upper lid. Gutta-percha drains were placed, and the wound was loosely sutured.

Temperature ranged between 101° and 102° for the next nine days. August 14, an external left ethmoidectomy and Lynch operation was performed by Knopf and

A.



B.

Fig. 4.—Patient S. P. *A*. A. P. x-ray film showing skull defect extending beyond the median line. No evidence of extension of infection. Two months postoperative. *B*. Lateral view of x-ray film showing size of skull defect.

Dunn on the right side, with anterior ethmoid perforation into orbit. Ethmoids were found to be soft and mushy. The floor of the frontal was removed; polypoid lining. Iodoform gauze pack from frontal sinus into nostril. Tube drain was placed from nose out to the angle of the wound. Rubber dam drain outer angle. Temperature declined and ran between normal and 101°. Patient complained of but little pain.

August 29, evidence of edema and fluctuation over the right frontal area was noted. August 30, x-ray films showed extensive osteomyelitis involving almost the entire right half of the frontal bone extending well into the midline and almost to the coronal suture (Figs. 3*A* and *B*). The frontal sinus was cloudy, as at previous examination made August 5, and no films were made in the interim.

A.

Fig. 5.—Patient S. P. *A.* Appearance of wound on sixth postoperative day after removal of gauze beneath flap overlying dura. Bone edges becoming covered with granulation. Dura covered with healthy red granulations. Bleeds freely. Skin clips removed from scalp on fourth day. *B.* Appearance of wound with gauze beneath flap before its removal on tenth postoperative day.

September 1, W.B.C. 13,850, polymorphonuclears 72. Transfusion of 400 c.c. blood. September 3, x-ray films showed no appreciable change in involved area since August 30.

I saw the patient on September 3. His appearance was as shown in Fig. 3*C*. Temperature was 100.4°, pulse, 98. Radical skull resection for osteomyelitis was advised. This was done on the following day, September 4, under avertin and ether anesthesia.

There was marked edema and swelling of right frontal region of both eyelids of right eye. Three discharging sinuses, each presenting a rubber tube, were present in incisions made for drainage of orbital abscess and abscess of the scalp. "Potts'

puffy tumor'' had previously existed. The outer table of skull presented typical moth-eaten appearance of extensive osteomyelitis with numerous sequestra. That portion of the bone over and adjacent to right frontal sinus was reddish in color, while that above the broken-down area was whitish, or yellowish white. There was an extradural abscess which did not extend far beyond the 2 by 2½ inch broken-down area. The dura was markedly thickened, with heaped-up granulation tissue here and there adherent to pieces of necrotic bone. There was no sinus leading down through the dura. The frontal sinus contained thick yellow pus, a culture of which showed *Staphylococcus aureus*. The operation was carried out as described (Figs. 1 *a*, *b*, and *c*). (These drawings were made from another patient.) Resection of skull

B.

was extensive, and it was not removed in one piece. The size of the defect is shown in Figs. 4*A* and *B*. Afterward the patient was given a transfusion of 450 c.c. of blood by Eggston.

Azochloramid solution was instilled into the dressing every two hours. Skin clips were removed from scalp margins on the fourth day. Temperature was normal on the sixth day, and gauze packing was removed from beneath the scalp flap under avertin anesthesia. Condition of the operative area was good (Fig. 5*A*). The flap was replaced, but not sutured.

Second removal of gauze beneath the flap (Fig. 5*B*) was done on the tenth day under avertin anesthesia. Temperature was normal. The flap was loosely sutured in position, gapping at intervals. Four days later, sutures were removed, and the troughlike area about the flap remained until healed by granulation (Figs. 6*A* and *B*). Bone edges were well covered. Temperature remained normal throughout

remainder of the patient's stay in the hospital. The patient could have been discharged to outpatient department a month following operation, but was retained until the wound was completely healed. He was discharged completely cured on the sixty-second postoperative day. He had gained eighteen pounds in weight while in hospital. Radiographic films (Figs. 4*A* and *B*) were made on the day of discharge and showed no evidence of recurrence of the disease. He has remained well since.

A plastic procedure for cosmetic reasons will be done at an early date, although the appearance of the scar at the present time is not very disfiguring. Bone regeneration has taken place to a marked degree.

This was indeed a satisfactory result. It is believed that similar results should be obtained in a majority of cases of osteomyelitis of the frontal bones and of the other bones of the cranial vault, provided the only complications are extradural and subperiosteal abscesses.

RESULTS AND COMMENTS

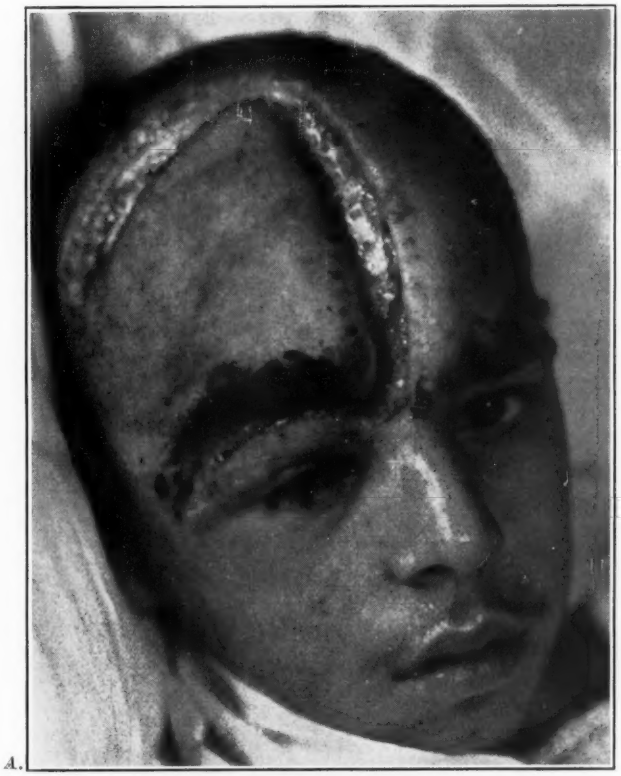
A fairly large number of cases of local osteomyelitis following gunshot wound of the skull observed in Germany and in this country during the late war, infected compound fractures, electrical burns, severe damage or avulsion of the scalp, etc., are not included in this series. These conditions do not belong properly in the category of the cases under consideration. I performed a cranioplasty on two cured cases of John McCoy, to one of which he made reference in his discussion of a paper by Bulson in 1925. These cases are excluded.

The series includes seventeen patients, twelve males and five females. The average age was thirty years. Eight were twenty-two years old or less. The youngest was one year, and the oldest fifty-six. Six were over forty years of age. *Staphylococcus aureus* was the predominating organism. The source of infection was the frontal sinuses and ethmoids in thirteen cases. Three were metastatic; one secondary to a lung abscess; one to a blood stream infection following an infected wound of the hand; and one to osteomyelitis of tibia and femur.

Only two patients had not been operated upon previously for some condition, and in these two the frontal sinuses had been probed. Several cases had undergone multiple operations. Ten recovered, seven died.

Of the seven who died, four were hopeless cases from the time they were first seen by the author. One had generalized osteomyelitis involving the entire cranium, both mastoid processes, right malar bone, and left mandibular articulation. How far it extended into the base was not known. Radical operation could not be done. Autopsy was not performed.

One patient had generalized osteomyelitis of the skull which apparently was being controlled when metastasis to the cervical spine occurred, followed by meningitis. Another had pansinusitis, followed by rapid generalized osteomyelitis of the skull without breaking down of either table, with a large extradural "lake" of pus, and meningitis.

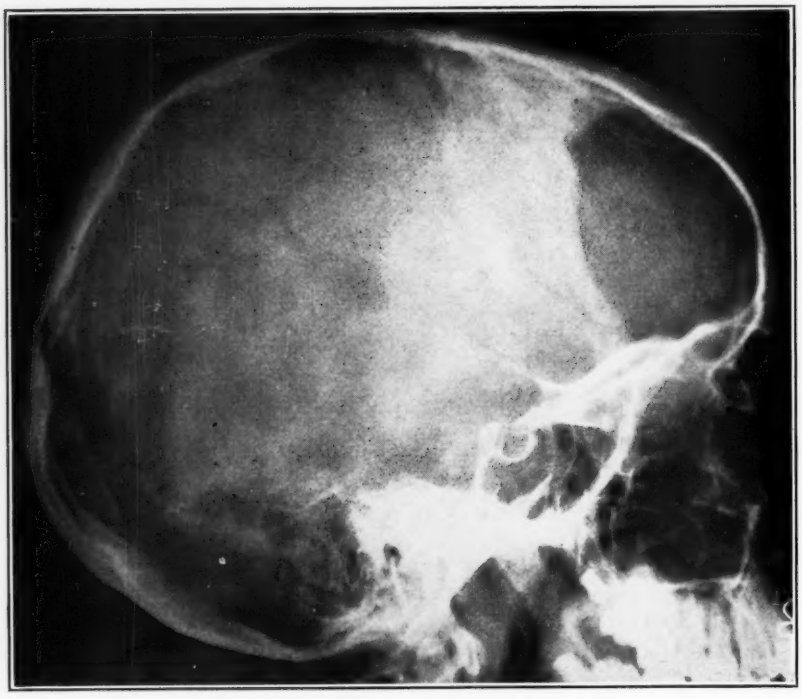


A.

B.

Fig. 6.—Patient S. P. *A*. Appearance of wound on twenty-fifth postoperative day. Bone edges well covered with healthy granulations. *B*. Appearance of wound on fortieth postoperative day. It is practically healed. Only a small dimple remains at median inferior angle. Frontal sinus obliterated.

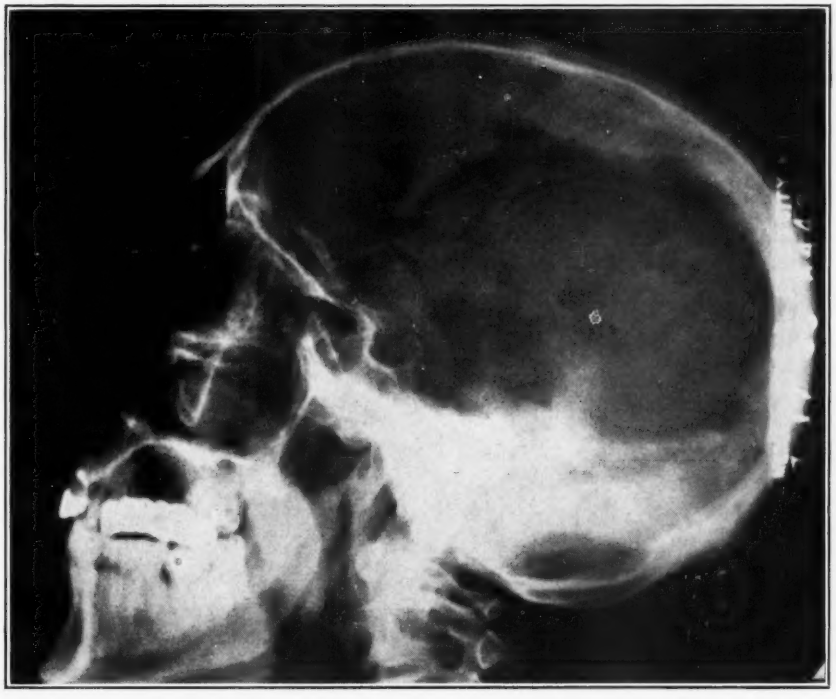
A.



B.

Fig. 7.—X-ray films showing size of skull defects following radical resection. *A.* C. B., seventy-seventh postoperative day, August 11, 1933. *B.* D. B., fortieth postoperative day, November 6, 1935. *C.* J. C., fifteenth postoperative day, July 17, 1935. *D.* Bloc of skull, 3 by 4 inches, removed from skull of patient, J. C.

The fourth patient had a brain abscess which had already ruptured into the meninges, and suppurative leptomeningitis had developed.



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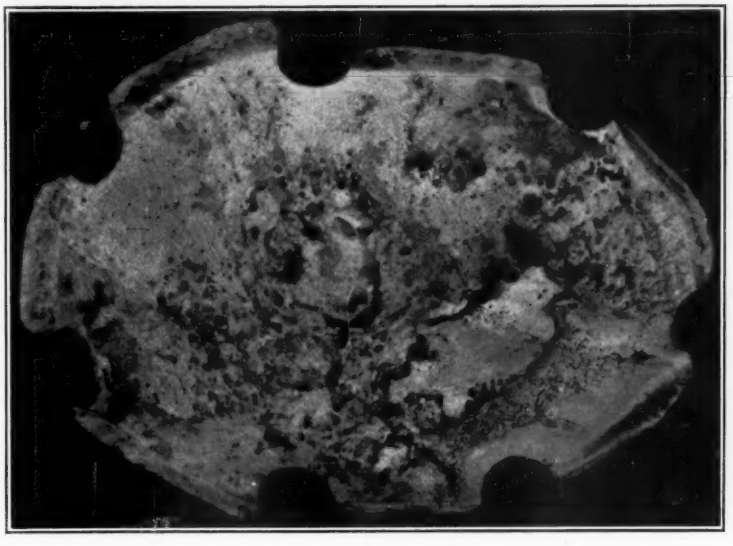

D.

Of the other three who died, one had marked involvement of the right side of the skull with multiple brain abscesses. Another was a woman of fifty-six years of age, in whom a frontal lobe abscess was

suspected, and in whom a large suppurating mass in the right upper abdominal quadrant developed and was aspirated. She was too ill for drainage of either area.

The seventh case probably should have recovered. An underlying brain abscess was suspected, but aspiration through infected dura was deemed inadvisable. Ventriculograms were not made. While I was attending a surgical meeting, the patient, who had been doing reasonably well, became comatose with sudden high elevation of temperature, and died. His death was most likely due to spontaneous rupture of an abscess into the ventricle. Autopsy was not performed. This is the only one of the seven cases on whom the desired radical resection of the skull was done. It could not be done in the other six.

Of the ten cases who recovered, the disease in two of metastatic origin affected the parietal bone of one side. In one, a single operation was performed. In another, multiple resections were done. The latter lost over half of his cranium. In the third case of metastatic origin, the frontal bone was involved. A single operation was performed. In the remaining seven, the disease involved only the frontal bone, five extensively. In two, the incision advocated by Mosher was used. One patient was operated on by Richard Atkins, and I operated upon her for a brain abscess. The second operation was performed by Edgar M. Pope under my direction. The other five patients were operated upon as desired, according to the method described. Only one of the ten patients was operated upon more than once for osteomyelitis. The longest time since operation is over three years, and the shortest three and one-half months. The best results have been obtained in the last few years by the initial complete resection of diseased bone.

SUMMARY

1. Treatment of osteomyelitis limited to the bones of the *cranial vault* is considered. Treatment of disease involving the accessory nasal sinuses per se, mastoid, petrus, maxilla, mandible, and basillar portion of the skull is not within the scope of this paper.

2. Earlier diagnosis can be made by more frequent x-ray examinations after the disease is suspected. The softened and partially decalcified region of the skull can be recognized several days before the moth-eaten appearance accompanying actual necrosis is observed. Exploratory drill hole may be done and diagnosis established. Earlier operation can then be instituted.

3. Preliminary ventriculograms—not encephalograms—are advised for the purpose of diagnosing and localizing a brain abscess when its existence is strongly suspected as a complication, provided the general condition permits. A brain abscess can be opened at the time of

operation for osteomyelitis. Dangerous transdural punctures, which might produce an abscess, were it not already present, and rupture of the abscess into the ventricle, would be prevented.

4. Special points in the operative procedure and postoperative course have been emphasized.

5. Closure of the skull defect following radical resection by regeneration of bone occurs, completely in younger people in the absence of prolonged infection and reinfection. Bone regeneration renders implantation and transplantation unnecessary.

6. "Conservative treatment" can be advised only in the most serious cases complicated by sepsis, meningitis, etc. Most of these cases will die in any event. Radical resection of all diseased bone is advocated and urged whenever possible. Halfway measures are condemned. Cure can and should be expected in the majority of cases with no complications other than extradural and subperiosteal abscesses. In other words, if the operation which was advised by McKenzie is properly done, most cases should live.

7. Results. Seventeen cases were operated upon, three of metastatic origin. Ten recovered, seven died. Six of the latter had but little chance of surviving when first seen by the author. One probably died from rupture of a suspected but undiagnosed brain abscess.

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PHYSIOLOGIC EFFECTS PRODUCED BY ABLATION OF THE AUTONOMIC CENTRAL INFLUENCE. VARIOUS FORMS OF SYMPATHECTOMY IN THE TREATMENT OF DISEASES*

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INTERRUPTION of sympathetic fiber tracts in the treatment of various diseases reveals interesting clinical and physiologic findings. These suggest that the fault in the autonomic mechanism is located in the centers of the cerebrospinal system rather than in the peripheral system. The fact that the smooth muscles of the blood vessels and visceral organs, the cardiac muscles, pilomotor muscles, and the sweat, sebaceous, salivary, and other secretory and excretory glands are innervated by fibers from the autonomic nervous system indicates that pathologic states may arise from excessive or decreased stimuli carried over this nervous system. The rationale of surgical treatment of these various diseases is to regulate the number of stimuli by sectioning sympathetic pathways, rami and trunks, and to remove sympathetic ganglions in order to decrease the number of central impulses carried to the organ or tissue involved.

ANATOMY

The following brief review of the anatomy and fundamental physiology involved is presented with the hope that it may aid in a better understanding of the reactions that follow various types of sympathectomy:

According to White,[58] "the autonomic system, in both its cranial and thoracolumbar divisions, is developed from migrating cells which leave the brain stem and spinal cord in the early stages of embryonic development. These cells continue to divide by mitosis and thus form the peripheral visceral plexuses. Consequently, there is no fundamental difference between the autonomic and the cerebrospinal neurones."

Gaskell[31] and Langley[40] classified the autonomic nervous system into two main anatomic and functional divisions: the *sympathetic*, or thoracolumbar outflow, and the *parasympathetic* or craniosacral division. The *cerebral* representation of the sympathetic outflow is presumably located in the paraventricular nuclei of the third ventricle of the hypothalamus, just posterior to the stock of the pituitary body.

The investigations of Beattie, Brow, and Long (1930)[11] have shown the connection between the paraventricular nuclei and the lateral horn

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cells in the thoracic region of the spinal cord. These fibers, in traversing the cord from the medulla, follow rather closely the pyramidal system. White rami communicantes composing the thoracolumbar outflow originate in cell bodies located in the lateral columns of the anterior horns, and the fibers leave the cord by the ventral roots of the spinal nerves from the first thoracic to the second lumbar segments. These fibers invariably make synaptic connections with sympathetic neurones, which, as postganglionic rami, communicate with the visceral organs or the structures of respective somatic segments. According to Gagel,[30] anatomic studies show that autonomic control from these higher areas is transmitted to the peripheral plexuses through a series of nuclei in the medulla which lie close to the midline in the floor of the fourth ventricle. Another important reflex center in the medulla lies beneath the calamus scriptorius at some distance from the midline. These reflex centers appear to act as regulatory mechanisms, since the cardiac, respiratory, and vasomotor centers are closely associated with the motor nucleus of the vagus nerve.

The *parasympathetic* cerebral representation is presumably located in the hypothalamus, anterior to the sympathetic centers, in the supraoptic, tuber cinereum, and mammillary nuclei. The *cranial fibers* of the parasympathetic group leave the brain by way of the third, seventh, ninth, and tenth cranial nerves. The vagus is by far the most important of the involuntary nerves; however, it should be borne in mind that the vagus nerve is composed of involuntary and voluntary fibers. The *sacral parasympathetic* outflow leaves the spinal cord with the second, third, and fourth sacral nerves. After the mixed nerves have passed through the sacral foramina, these pelvic nerves (nervi erigentes) do not continue with the white rami to the sacral sympathetic ganglions, but run directly into the hypogastric ganglion and thence to the walls of the pelvic viscera. Their postganglionic neurones lie in the intrinsic plexuses of the genitalia, bladder, and rectum.

Papez and Aronson (1934)[46] have recently summarized the anatomic and physiologic data concerning the nuclei in the hypothalamic areas which have been shown to coordinate visceral activity and, to a large extent, to regulate human emotions. Fulton and his colleagues,[29] in their investigations, have found a certain degree of vasomotor and intestinal localization in the cerebral cortex, area 6 of Brodman. As expressed by Clark (1932),[18] "the hypothalamus is the recipient of those vague and indefinable impressions which arise in association with all sorts of visceral activities and metabolic processes. Through its nervous connexions, and through the direct liaison which it establishes with the endocrine regulatory system via the pituitary, it mediates the integration of the visceral impulses and plays an essential part in the control of the internal milieu of the organism."

For a detailed review of the anatomic relationship of the autonomic system, I am much indebted to Ranson[52] and Kuntz,[39] since I have frequently referred to Ranson's, "Anatomy of the Nervous System," 1928, which contains a very thorough neurohistologic review, and to Kuntz's, "Autonomic Nervous System," 1929, which presents a correlation of anatomic, physiologic, and pathologic facts. White's[58] "The Autonomic Nervous System" has proved of inestimable value as a reference, since it contains, in condensed form, data pertaining to the anatomy and physiology and to the surgical treatment of diseases arising from dysfunctions of the autonomic nervous system.

PHYSIOLOGY

The character of this paper does not permit full discussion of all physiologic reactions arising from stimuli carried over the autonomic nervous system. I shall, therefore, quote a summary from White's book, but before doing so, much credit should be extended to Professor Cannon and his collaborators who have extended the investigations of Claude Bernard,[12] Gaskell,[31] and Langley,[40] who in turn are chiefly responsible for our present understanding of the physiology of the sympathetic nervous system:

"One of his (Cannon's) greatest contributions to this subject has been his observations on animals which have been totally deprived of sympathetic activity by removing the paravertebral ganglia from the neck to the lower lumbar regions (Cannon et al., 1929).[17] These animals have lived in the sheltered conditions of the laboratory in good health for years. The animals become very sensitive to cold, as they have lost the ability to conserve heat. Erection of the hairs is permanently lost, but the peripheral arteries recover a degree of local vasomotor tone. Ability to perform muscular work and to resist fatigue is greatly reduced. These animals show no tendency toward vagotonia, as digestion is unchanged, the heart rate is only slightly slowed, and the blood pressure remains little altered. The basal metabolic rate is reduced about ten per cent. The cat becomes pregnant and reproduces in a normal manner, but is unable to nurse her young (Cannon and Bright, 1931).[16] There are no noticeable growth changes in kittens which have had a total sympathectomy performed on one side. This shows that the sympathetic nervous system is relatively unimportant in a protected constant environment, but emphasizes its essential character in the conditions of stress and strain which are met in normal existence.

"In summing up the rôle of the *thoracolumbar* division of the involuntary nervous system, we should think of it as an emergency protective mechanism, which may not be functioning all the time, but which is always ready to go into action to combat any variety of adverse circumstance. Some of the most common conditions which arouse its activity are pain, extremes of temperature, asphyxia, haemorrhage, infection, dehydration, and hypoglycaemia. Furthermore, any form of intense emotion or psychic trauma may stimulate a generalized sympathoadrenal discharge...

"Since the functions of the sympathetic nerves are catabolic and give rise to an extraordinary liberation of body energy, they are of a spendthrift character. Of equal importance to the body are the anabolic functions of the craniosacral *(parasympathetic)* division, which come into play during the periods of rest and recuperation and are of a conservative character. In summing up their activity I shall

again make extensive use of Cannon's[15] excellent exposition in *The Wisdom of the Body*. The functions of the cranial division are carried out by a group of reflexes, conservative, protective, and up-building in their service. By narrowing the pupil the retina is protected from excessive light. By providing for the flow of saliva and gastric juice, and by increasing the tonic state of the gastrointestinal canal, proper digestion, absorption, and elimination of food substances are assured. Further evidence of the conservative influence of cranial autonomic tone is seen in the provision for rest and recuperation of the cardiac muscle by vagal slowing of the heart rate.

"The function of the *sacral division* is in the main to empty hollow organs which are periodically filled. Sacral autonomic impulses cause contraction of the lower colon, rectum, and urinary bladder. At the same time the involuntary sphincters of these reservoirs are relaxed. While less is known concerning the functional innervation of the reproductive tracts, it is probable that these are put in a state of sexual activity by parasympathetic impulses, as it is well known that they are inhibited by the opposed activity of the sympathetic system.

"It is apparent that these two great systems, which control the activity of our circulatory, respiratory, digestive, and genito-urinary systems, are in a state of balanced opposition. Like the balanced tone of the extensor and flexor groups of muscles described by Sherrington, when one is excited, the other is inhibited. While the effect of the sympathetic impulses is very diffuse, the opposed effect of the parasympathetic is more specific. Between the two every type of response, both general and local, is provided for. As Cannon puts it, 'all the viscera can be influenced simultaneously in one direction or the other by varying, up or down, the . . . tonic activity of the sympathetic division. And any special viscus can be separately influenced . . . by varying . . . the tonic activity of the special nerve of the opposed cranial or sacral division that reaches directly to the viscus. Thus the heart may beat rapidly because the effect is part of the total complex of effects on the viscera produced by the sympathetic in emotional excitement; . . . or it may beat rapidly without extensive involvement of other viscera because of a lessening of vagal inhibition. The sympathetic is like the loud and soft pedals, modulating all the notes together; the cranial and sacral innervations are like the separate keys. When we consider that in emergencies the sympathetic functions in a great variety of ways serve the organism as a whole, the importance of its arrangement for simultaneous and unified action becomes evident.'

"This co-ordination of the body as a whole to meet changing conditions in its external or internal environment by automatic adjustment has been called 'homeostasis' by Cannon (1929B).[14] Homeostasis frees the individual from the difficult task of paying routine attention to the management of the details of bare existence. Without homeostatic control the warm-blooded animal would be in constant danger of disaster, unless always on the alert to correct voluntarily what the vegetative system regulates in a purely automatic fashion.

"All automatic mechanisms, even the most efficient, may cease to function smoothly. The normally efficient homeostatic control may break down in certain abnormal conditions. For instance, many individuals suffer from chronic vasoconstriction in the extremities; their hands and feet are constantly cold and moist from excessive perspiration. In other instances the heart may overaccelerate at the slightest stimulus, or food may fail to progress along the gastro-intestinal canal at a normal rate. When these extreme reactions continue, they result in clinical syndromes such as Raynaud's disease, neurocirculatory asthenia, and megacolon, as well as in a host of vague symptoms which cannot be classified under any definite diagnosis. . . .

"In 1876 Eulenburg and Landois[28] observed a rise in skin temperature of the contralateral extremities on ablation and a fall on stimulation of the motor-sensory area. These experiments have recently been repeated and corroborated by Pinkston, Bard and Rioch (1934).[50] Gowers and Bechterew have cited cases of hemiplegia and traumatic lesions near the 'central gyrus' in man with increased temperature of the contralateral half of the body. An interesting case showing unilateral vasomotor disturbance has recently been reported by Kennard, Viets, and Fulton (1934).[37] In this patient a tumour of the right premotor cortex caused redness, heat, and sweating over the entire left side of the body. . . .

"In a case of diencephalic tumour, reported by Penfield (1929),[48] extraordinary outbursts of autonomic activity appeared in repeated attacks. These manifestations consisted of cutaneous vasodilatation, salivation, sweating, and pilomotor activity. Tears flowed from both eyes, the pupils dilated, and in severe attacks the eyeballs protruded. The heart-beat became strong and rapid, while the respiration was slowed. Following an attack the woman became constipated and experienced difficulty in emptying her bladder. She finally died after a prolonged series of attacks. Post mortem examination revealed a cholesteatoma of the choroid plexus which protruded into the foramina of Monroe, causing an internal hydrocephalus. This tumour lay close to the region delimited by Bard.

"After working on the same subject from another angle, Cushing (1931 A and B)[23, 24] has reported a series of interesting observations on the effects of pituitrin and pilocarpine injected into the cerebral ventricles. As is already well known, the hormone from the posterior half of the gland when injected intravenously causes vasoconstriction and stimulation of the muscle in the lower bowel. When introduced into the ventricle, on the contrary, Cushing found it to cause flushing, sweating, salivation, vomiting, and a pronounced fall in body temperature—a generalized parasympathetic response. Pilocarpine introduced into the ventricle gave a very similar response. The effect of both drugs was abolished by atropine, a further indication that the phenomenon was due to a parasympathetic discharge. In cases where the autonomic centers in the diencephalon were infiltrated by tumours, this reaction failed to take place. He observed that the effect produced on the parasympathetic system appeared to be as diffuse in its character as the response of the sympathetic to adrenaline. He believes that the active principle of the neurohypophysis reaches the autonomic nuclei in part by diffusion through the cerebrospinal fluid and in part through the blood."

PHYSIOPATHOLOGIC OBSERVATIONS

Though it is possible to understand that the autonomic nervous system controls the homeostasis of a normal individual, it is much more difficult to understand why a certain component of this system should fail. It is possible for an organic lesion to affect or destroy a part of the autonomic system. If the lesion is of an irritating character, the autonomic impulses may be intensified or increased in number. Destructive lesions would produce the opposite effects, inasmuch as nervous pathways would be destroyed or reduced in number; but in either case the muscular balance of visceral organs, vasomotor control, or glandular secretion would be disturbed. Neoplastic and vascular lesions of the premotor, motor, and hypothalamic areas with similar lesions and traumatic myelitis of the spinal cord have produced innumerable illustrations of autonomic disturbances.

Since autonomic disturbances manifest themselves in one person in the form of vasomotor spasm affecting the arteries of the hand, while in another, vasomotor spasm may be more marked in the principal arteries of the feet, and still others will complain of hyperhidrosis, essential hypertension, megacolon, and so forth, it occurred to Craig and Kernohan[21] that it might be worth while to make a careful histopathologic study of the sympathetic ganglions and trunks which were removed for the specific purpose of effecting vasodilatation in the treatment of Raynaud's disease, thromboangiitis obliterans, the acral type of scleroderma, and the rheumatoid type of polyarthritis affecting the hands and feet. Their study consisted of a review of the sympathetic ganglions in 208 cases in which such ganglions were removed in connection with both cervicothoracic and lumbar sympathetic ganglionectomy.

According to Craig and Kernohan:[21] "It had been noted that in a certain number of operations for the removal of sympathetic ganglions, indications of inflammatory reaction in both the posterior mediastinum and in the postperitoneal tissues were found. In the abdomen, enlarged lymph nodes frequently interfered with the exposure of the sympathetic chain to such an extent that it was necessary to dissect and remove them before the operation could be completed. Although enlarged lymph nodes were not encountered in the mediastinum, the difficulty of dissecting the sympathetic trunk due to adhesions suggested the presence of mild mediastinitis. These observations at operation raised the question of local inflammatory reaction playing some part in the dysfunction of the sympathetic system by involving the ganglion tissues and cells. In addition to the histologic examination of the ganglions removed, bacteriological examinations were also made, which were essentially negative in the entire series.

"A control series of forty nonoperative cases were used, and the corresponding sympathetic ganglions were removed at postmortem and examined in a similar manner. In none of these cases was there any clinical evidence of the four conditions which constituted the basis of this study.

"In comparing the histologic observations of the sympathetic ganglions, as evidenced by the van Gieson stain, haemotoxylin and eosin, thionin, Orlandi silver impregnation method, Hortega's silver carbonate method, Cajal's gold chloride and sublimate method, nothing was found to explain the various vascular disturbance. All the changes were within normal limits and could be explained on the basis of advancing age. There was no histologic difference between the ganglions removed for the various diseases, although these varied much in their clinical manifestations. The blood vessels in the ganglions removed from patients with vascular diseases did not partake of the changes in the blood vessels of the diseased extremity and were similar in most respects to the control vessels. Small collections of lymphocyte-like cells were present in all the ganglions, including the control ganglions. Sympathetic ganglion cells are surrounded by a delicate capsule which is covered on the outside by a layer of flattened, elongated cells of connective tissue origin and are referred to as ectocapsular cells, whereas the inner side of the capsule is lined with a layer of cells which have been called endocapsular 'amphicytes' or 'satellite cells.' There were no characteristic histologic changes in either of these groups of cells. Vacuolization was noted in all of the ganglions and was considered to be the result of acute swelling of the endocapsular cells which occasionally contain mucus. Pigment granules in the cells of the sympathetic ganglions were found to increase with the age of the patient, so that in elderly persons most cells contained numerous

pigment granules. The pigment was found to be of two types, the lipochrome or fat-containing pigment which stained with sudan III, and the fat-free type which had an affinity for silver.''

From all their histologic observations Craig and Kernohan came to the conclusion that the noxious agent which caused the vascular diseases and for which operative relief had been instituted did not act on the sympathetic ganglions removed and that the ganglions act simply as relay stations for impulses from high centers where the disease originates.

CLINICOPHYSIOLOGIC OBSERVATIONS

As I observe patients with various diseases resulting from dysfunction of the autonomic nervous system, I am impressed with the fact that these individuals must be born with unstable autonomic nervous systems. Vasomotor disturbances of the extremities, when they occur, make their appearance early in life and usually afflict young asthenic females. Not infrequently some newborn infants have megacolon, and others have disturbances of the bladder and urinary retention without the presence of demonstrable etiologic factors. It would thus appear that the greater number of these individuals have an autonomic nervous system that is constitutionally inferior. They have an autonomic mechanism capable of coping with a protected environment, but they do not have one that can adjust the body to all emotions and physical demands. With the continued call on reserve energy, the autonomic mechanism of these people breaks down and produces a diseased state. It no longer serves as a regulator, but may act either as an accelerator or as a depressor mechanism.

Psychic influences play important rôles in diseases which result from dysfunction of this nervous system. Mental fatigue, worry, fear, and anger will aggravate vasomotor disturbances such as Raynaud's disease, while a change of environment, physical and mental rest, and contentment will ameliorate the symptoms.

The heat-regulating mechanism exercises considerable control over the vasomotor and sudomotor functions. Strenuous physical exercise produces a flushing of the skin and perspiration. The vasoconstrictor impulses are undoubtedly inhibited; thus arteries of the skin are permitted to relax and to increase in caliber in order to allow more blood to reach the surface, there to be cooled and to lower the body temperature. It is possible that there is a direct vasodilatation impulse which aids in affecting arterial relaxation; but, as yet, the anatomy and physiology of this phenomenon have not been indisputably settled. The excessive perspiration accounts for increased heat elimination by evaporation. Increased metabolism from excessive ingestion of food, environmental heat, hyperthyroidism, fevers and protein reaction, and artificial fevers, produce vasomotor and sudomotor responses similar to those that follow strenuous physical exercises.

Drugs appear to have selective action on the sympathetic and parasympathetic system. Some stimulate and others depress the central activity. Other drugs appear to affect the endings of the peripheral neurones. The ingestion of alcohol, for instance, increases metabolism, but not to such an extent as to account for the sudden and marked vasomotor relaxation that it produces. It appears that alcohol stimulates the heat-regulating mechanism, which in turn inhibits the vasoconstrictor responses. The vasodilating effect of alcohol, like that of induced fever from administration of foreign protein, serves as a therapeutic agent in the treatment of vasospastic diseases.

Nerve blocks by local anesthetics produce temporary vasodilatation and cessation of perspiration. Spinal anesthetics produce similar effects over wider areas in addition to the motor and sensory anesthesia. However, a general anesthetic like ether produces a vasodilating effect which lasts from three to five days. The maximal vasodilatation response occurs as soon as the patient is thoroughly anesthetized. It then continues for from ten to fifteen hours, when the effects gradually taper off. If an operation is prolonged or much blood is lost, the protective measure of vasoconstriction overpowers the vasodilating one, and the skin will blanch and become cool and moist. The sudomotor reaction is more marked during the flushed or vasodilating phase than during the phase of shock.

VASOMOTOR REACTIONS

The rationale of sympathectomy[44] in the treatment of vasospastic disease is based on the theory that interruption of sympathetic pathways will reduce sufficient vasoconstrictor impulses to prevent vasospasm and permit return of a normal circulation.

There are two schools of thought concerning the cause of the vasospastic disease known as Raynaud's disease. The adherents to Raynaud's conception believe that vasomotor spasm involves small arteries, arterioles, capillaries, and venules, that the vasoconstrictor impulses are of central origin and are initiated by a faulty central sympathetic mechanism, and that the local reactions to cold temperatures are normal reflex responses superimposed on a state of chronic vasospasm. The other school[38, 43] holds that defective circulation is due to a fault of the digital arteries and vessels of smaller caliber, without spasm of the veins, and that the phenomena are produced by cool temperatures and are relieved by heat.

The medical vascular and neurosurgical staffs of the Mayo Clinic have had occasion to study thoroughly, preoperatively and postoperatively, ninety-two cases of Raynaud's disease in which patients were submitted to some type of sympathectomy. The operations have varied in their scope, since they were changed from time to time during the developmental stages of the operative measures. The postoperative

results have been followed for periods of a few months to ten years. The opinions I shall give are the composite ones arrived at by the two staffs, Brown, Allen, Barker, Horton, and Roth, and Craig, Love, and myself, who have studied these cases. We neurosurgeons have also operated upon a number of other patients with diseases that are influenced by vasomotor spasm; namely, 154 patients with thromboangiitis obliterans, thirty-four with scleroderma, seven with hyperhidrosis, forty-three with peripheral rheumatoid arthritis, and thirty-six with essential hypertension. It is not the purpose of this paper, however, to discuss surgical indications and selection of cases, since it is intended to record observations to substantiate the theory that pathologic states result from a dysfunction of the central autonomic mechanism. The numerous operative procedures performed on the sympathetic nervous system have permitted me to compare the physiologic and pathologic findings before and after section of rami and removal of ganglions and trunks.

Blanching of the skin on exposure to low temperature, or on subjection of an individual to sudden fright, is a normal reaction, as is flushing of the skin when local heat is applied or when an individual is suddenly embarrassed. These normal reactions vary in individuals, and thus it is apparent that they can be initiated as easily by psychic influences as by local thermal factors. Since these same phenomena of blanching and flushing combined with sweating are important factors in regulating body temperature, it would appear that they were more or less subservient to the central heat-regulating mechanism. It is also a known fact that blanching of the skin, vasoconstriction, takes place during a chill, regardless of bed covering and room temperature, and that flushing of the skin appears during the height of fever in a cool room.

The mechanism of vasoconstriction and vasodilatation is not as simple a reaction as is contraction and relaxation of skeletal muscle, since the cardiac and vascular musculature is kept in tone by pressor and depressor substances which circulate in the blood stream. Changes in concentration of these substances will change vascular tone, but these substances are not normally secreted in such amounts as to produce pathologic lesions, unless "essential hypertension" is the result of such a condition. Thus it appears that a direct neurogenic vasoconstrictor impulse is necessary to produce sufficient vasospasm to decrease the blood supply until death of tissue results.

RAYNAUD'S DISEASE

Since Raynaud's disease[1, 6, 53] represents the typical phenomenon of vasospasm, which varies in degree from mild discomfort to ulceration, gangrene of digits with scleroderma,[13] and dactyle arthritis,[32] it will serve as the theme for discussion. Its amenability to various forms

of sympathectomy permits of preoperative and postoperative studies. One might try to present a composite picture in chart form of all our cases in which operation has previously been performed. Since the symptoms and reactions are similar, however, only varying in degree of severity, I believe the facts can be told more clearly by following the record of one case which presents most of the problems encountered in the treatment of vasospastic disease.[4, 5, 9, 26, 55, 57]

If we were to accept the theory that the changes in color of Raynaud's disease were due to a fault in the terminal arteries of the digits or in the smaller arteries of the skin, instead of a fault in the central mechanism, we would expect no psychic influences on these changes in color, nor would we expect the phenomenon of asphyxia or cyanosis to appear in patients residing in warm climates or living in an overheated room. Neither would we expect nerve block or interruption of postganglionic rami, various forms of sympathectomy, to alter the cycle of asphyxia, cyanosis, and rubor in patients, assuming of course that the environmental temperatures were the same postoperatively as they were during the tests taken preoperatively:

Typical Case of Vasospastic Disease.—A school girl, seventeen years of age, first registered at the clinic in March, 1926. She was native born of English descent. Her chief complaint was of drawing pains in the right lower abdominal quadrant. She was also troubled with constipation, frequent headaches, and insomnia. General examination revealed nothing definite, and the neurologist concluded that she was suffering from nervous exhaustion, since the laboratory and physical examinations revealed no evidence of Raynaud's disease or of any other physical defect. It was apparent that the patient at this time was having difficulty in adjusting herself to her environment, as it had become necessary for her to stay out of school two or three days every week.

The patient again reported in March, 1932, with a history of vasomotor disturbance, complaining of whiteness and tingling of her fingers and toes; she did not complain of abdominal discomfort, headaches, constipation, or insomnia. She stated that she had first noticed these symptoms in the autumn of 1927, about eighteen months after her original visit to the clinic. As she went on to describe the onset of her symptoms, she stated that the first observations made were that, on awakening in the morning, the tip of her third finger on the left hand would become white, numb, and would tingle. Two or three months later she had noticed that the whole finger had become involved instead of just the tip. She said that she had been able to see the white line gradually advancing toward the hand. The changes in color, those of asphyxia, had lasted from three to thirty minutes, and at first had occurred only in the morning. In the spring of 1928, her big toe on the left foot had blanched, become numb, and tingled, simultaneously with similar symptoms in the third finger of the left hand. Within two months of the onset of the vasomotor changes in the big toe, all her toes and fingers of the left foot and hand, with the exception of the thumb, had gone through the same changes. In the autumn of 1928, the third finger on her right hand and her big toe on the right foot had been affected in a manner similar to that which had affected the corresponding fingers and toes of the opposite side. Two months later all of the toes and fingers on the right side had become involved, but the vasomotor reaction to asphyxia, that is, blanching, numbness, and tingling, had been still more intense on the left side than on the right. The patient said that there was no prickling sensation during the red

phase. By this time her typical attack consisted of a blanching period, of three to thirty minutes, which was followed by blueness of thirty seconds' to two minutes' duration and redness of thirty seconds' to three minutes' duration. She said that the longest white stage that she had ever experienced was that of two hours, and that it had affected her left big toe alone. She also said that the attacks of asphyxia, cyanosis, and rubor with the accompanying pain had been more prone to occur during damp weather or cold weather, especially so when she had been either physically or mentally fatigued, and that she had felt most comfortable when the climate was dry and warm.

On physical examination in March, 1932, at which time the patient was twenty-three years of age, she was five feet and three inches tall and weighed 105 pounds (47.6 kg.). Her normal weight should have been 120 pounds (54.4 kg.). The systolic blood pressure was 140 and the diastolic 96. She was anemic and asthenic in appearance, and had hypertrophic tonsils, but without evidence of free pus. Examination of her heart and lungs gave negative results. Examination of the abdomen and pelvis was also negative. The patient's hands were cold and clammy but were normal in color; her feet were cold but dry and presented a slight rubor over the toes. All the principal arteries of the extremities were open and pulsated normally. There was no evidence of scleroderma or arthritis. Special examinations, such as roentgenologic examinations of the lungs and spinal column, and examinations of the eyes, ears, and central nervous system were negative.

Examination of the blood revealed 4,610,000 erythrocytes and 7,300 leucocytes per cubic millimeter, and the value for hemoglobin to be 97 per cent. A flocculation test for syphilis was negative. Microscopic studies of the capillary loops at the nail folds showed the capillaries to be dilated and tortuous. The specific gravity of the urine was 1.024; it was acid in reaction, contained no albumin or sugar, and on microscopic examination was negative. The basal metabolic rate was +1 per cent. Electrocardiographic studies revealed sinus arrhythmia, slight right ventricular preponderance, a diphasic T-wave in derivation III, a transient exaggerated P-wave in derivation II, a notched P-wave in derivation II, and a slurred QRS in derivations I, II, and III.

Vascular studies were made on March 29, 1932, to determine the absence or presence of vasomotor spasm. The history of the attacks of blanching, blueness, and redness was rather typical of Raynaud's disease, although the patient could not produce the color changes as readily as many patients do in meeting strangers during the examination. The vasomotor studies definitely demonstrated that there was present a marked vasospasm in all fingers and toes. On the morning of March 29, at about 8 A.M., the patient was given an intravenous injection of Lederle's triple typhoid vaccine of 20,000,000 bacteria. The initial skin temperature read by the electrothermocouple was 22.4° C. for the left big toe, 22.2° C. for the right big toe, 25.0° C. for the right third finger, and 23.4° C. for the left third finger. At the height of fever reaction, the skin temperatures had risen to 34.5° C. for the left big toe, 34.8° C. for the right big toe, 37.2° C. for the right third finger, and 36.9° C. for the left third finger. This revealed an average rise of 12° C. temperature above the initial skin temperature before the injection of the vaccine. The fever reaction was rather mild owing to the rather small dose of vaccine employed, but since the surface temperature of the skin over the toes and feet rose so high, it became apparent to us that there existed a very marked vasospasm and that we were justified in advising and performing sympathectomy. Inasmuch as the symptoms involving the feet interfered with the patient's getting about, it was decided to perform bilateral lumbar sympathectomy first. However, in view of the fact that some investigators have reported improvement in the vessels affected by vasospasm, from roentgen therapy, as well as from roentgen treatment of the cervical ganglion, it was concluded that it might be well to give a course of treatment to the hands

before lumbar sympathectomy. Accordingly, on March 23 the patient received on each hand 275 roentgen units of high-voltage roentgen rays, or in other words one-half the erythema dose. She reported for a second course of roentgen treatments on June 3, 1932, and the roentgenologist, Dr. Desjardins, commented that little or nothing would be accomplished by roentgen treatments of the blood vessels of the hands, but that it might be well to continue with the proposed plan. The patient again received roentgen treatments of one-half the erythema dose, but this time the treatment was applied to the cervicothoracic region. She reported a third time, on July 1, and was given one-half of an erythema dose to the right hand. Subsequent follow-up studies showed that no improvement followed these roentgen treatments.

Bilateral lumbar sympathetic ganglionectomy and trunk resection, including the second, third and fourth lumbar ganglions on both sides, was performed April 1, 1932. There was nothing unusual about the ganglion operation or abdominal exploration. The patient's convalescence was uneventful and the result was satisfactory. The skin over the feet and the legs up to the knees became warm and dry and appeared slightly more pink than that of a normal individual. The patient's symptoms affecting the feet disappeared. The patient was cured and has had no evidence of any return of her symptoms in the feet. The color changes of asphyxia, cyanosis, and rubor have never reappeared, regardless of exposure to cold and damp weather; they have not occurred when the feet have been immersed in ice water, nor have they occurred from psychic influences.

The successful result of the lumbar sympathectomy encouraged one of the neurosurgeons to advise and carry out cervicothoracic sympathectomy, and this was performed September 24, 1932. Since difficulty was encountered at the time of operation, and the operation was not made as complete as it usually is, I shall take the liberty of quoting from the surgical record, since the surgeon who operated on this patient anticipated an incomplete surgical result. The surgical approach was a posterior one through a midline incision in the skin from the spine of the sixth cervical vertebra to that of the third thoracic vertebra. The aponeurosis of the trapezius, rhomboid, and serratus posterior muscles was reflected on both sides of the spinal column. The entrance on the right side into the postmediastinal space followed resection of a portion of what was supposed to be the first rib adjacent to and including the tip of the transverse process of the corresponding vertebra, but, instead, the entrance was through the second rib and exposure resulted in opening of the pleura. The opening was promptly closed by a stitch of catgut. The operation was continued. However, the entrance into the mediastinum by the way of the second rib not infrequently results in opening of the pleura, which can be obviated by entering the mediastinum following resection of the first rib. Though the entrance through the second rib permits removal of the first and second thoracic ganglions, it does not always permit removal of the lower cervical ganglion, the upper component of the stellate, or does it allow for division and ligation of the superior intercostal artery with its accompanying rami or permit as thorough ramisection of the lower trunk of the brachial plexus as is obtained by entrance into the postmediastinal space by the way of the first rib. This situation developed in this particular case.

At the same operation, following completion of the unsatisfactory sympathectomy in the right cervicothoracic field, left cervicothoracic sympathectomy was performed, employing the approach into the mediastinum through the space occupied by the resected portion of the first rib. The mental hazard of encountering difficulty on the right side more or less limited the activities on the left side and the surgeon was satisfied to remove only the cervicothoracic ganglion and intervening trunk without dividing the superior intercostal artery or the rami accompanying it and the rami ascending to the lower trunk of the brachial plexus from the second and third thoracic ganglions on the left side.

Postoperative convalescence was satisfactory in that the vasomotor symptoms were much improved; they were not completely relieved, however, inasmuch as localized areas of sweating persisted (Fig. 1), and slight changes in color would appear in limited areas. The symptoms were more marked on the right than the left side. Very soon after operation, however, a sweating area appeared on the dorsum of the left wrist which suggested that an incomplete operation had been performed.

In view of the surgical experience in the right cervicothoracic field, the surgeon advised reexploration of that wound, and this was carried out on October 10, 1932, this time resecting a proximal portion of the first rib and transverse process preliminary to entering the mediastinum. Numerous adhesions were encountered which

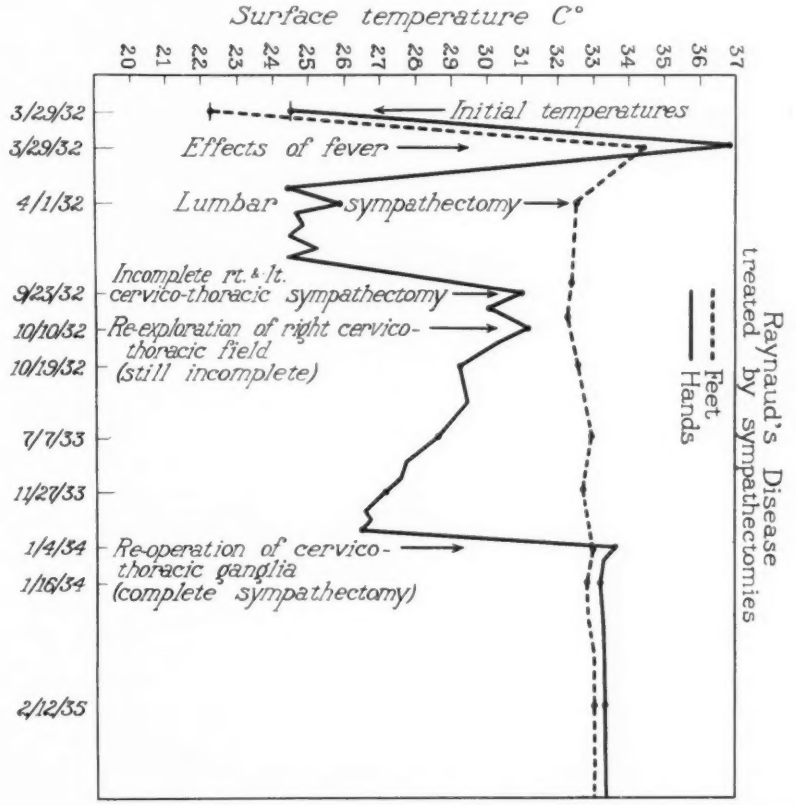

Fig. 1.—The three diagrams illustrate the effects on sweating which result from bilateral lumbar, incomplete cervicothoracic, and complete cervicothoracic sympathetic ganglionectomies. The incomplete effect of sympathectomy is always associated with incomplete vasodilating effects, thus it serves as an indicator concerning the thoroughness of the operation. Skin over areas not deprived of their sympathetic innervation gives evidence of increased sweating which appears to take on a compensatory function.

were due to the former operation, so that the surgeon again experienced unusual difficulty in completing as thorough an operation as is usually performed.

The patient made an uneventful convalescence and was dismissed. In the winter she had occasional episodes in the morning when blanching would occur in localized areas over the fingers, which were followed with but slight cyanosis and a short period of redness. There was no true pain, but there was some tingling in the fingers. She complained of excessive sweating over the trunk and especially about the waist. Sweating tests were made on her return, at this time, and they revealed

irregular sweating areas, more in number over the right hand than on the left. Vasomotor studies were made and now demonstrated that definite changes in color could be obtained by the ice water and psychic tests, but the range of color differed from that prior to surgical interference, since it now extended from a mild pallor to rubor and back to normal, eliminating the cyanotic phase. The episode of color change and discomfort was much less, and the patient volunteered the opinion that the improvement at this time was equivalent to from a 50 to 75 per cent cure.

The patient returned for another examination on November 6, 1933. (She lived but forty miles from the clinic and it therefore was rather convenient for her to return for these numerous observations, and she was hoping for relief in her hands equivalent to the relief obtained in her feet following lumbar sympathectomy.) Numerous studies of temperature were made, the results of which are presented in chart form for the sake of clarity and brevity (Fig. 2). The patient reported on this visit that all the fingers of both hands had become cold rather easily, that the

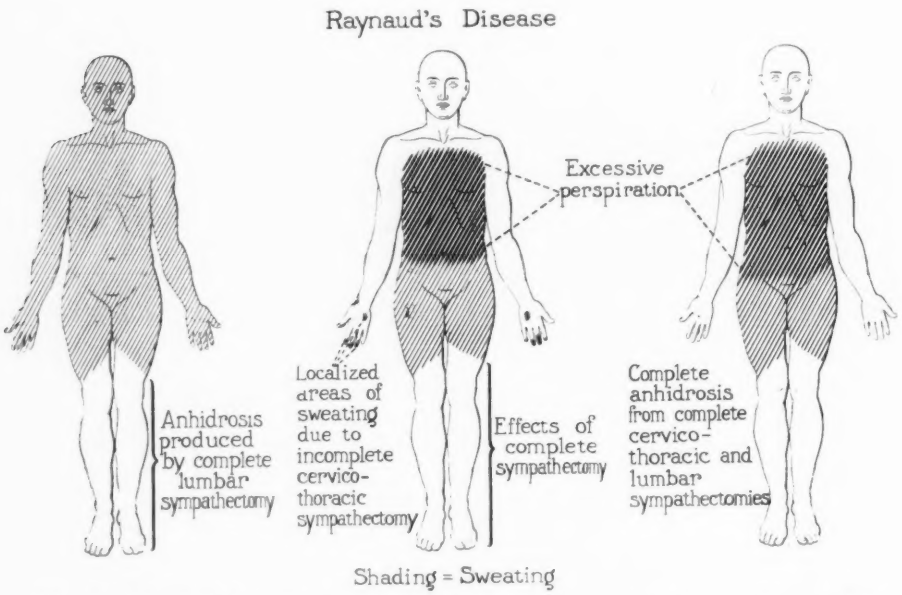
Raynaud's Disease
Excessive perspiration
Anhidrosis produced by complete lumbar sympathectomy
Localized areas of sweating due to incomplete cervico-thoracic sympathectomy
Effects of complete sympathectomy
Complete anhidrosis from complete cervico-thoracic and lumbar sympathectomies
Shading = Sweating

Fig. 2.—The initial and subsequent skin temperatures produced by fever and by complete lumbar sympathectomy, showing the effects produced by incomplete and complete interruption of vasomotor fibers to the terminal arteries of the digits in terms of skin temperature. These readings extend over a period of approximately three years. The permanency of the vasodilating effects produced is illustrated by these successful sympathectomies.

third finger on the left and second and third fingers on the right hand had become pale on exposure to cold, following which they had become red and had tingled before returning to normal. She further stated that at times all the fingers on her right hand except the thumb had become pale on exposure to cold. These findings suggested to me that the original cervicothoracic sympathectomies were incomplete, and I therefore advised the fourth operation: reexploration of the cervicothoracic fields and complete interruption of all vasomotor fibers to the hands.

The studies with thorotrast (Fig. 3) made by Allen revealed such attenuation of the digital arteries that it raised the question as to whether or not Raynaud's disease of the hands might be a different lesion than the one that affects the feet. However, subsequent thorotrast studies (Fig. 4) following the fourth sympathetic procedure disclosed the fact that these attenuated vasospastic arteries were thoroughly dilated by sympathectomy, and, on observation of these films, it is readily seen that the

thorotrast has filled the arteries to their peripheral ends. The fact that the recurrence of symptoms increased in severity as time elapsed following operation raised the question by the medical staff as to whether or not regeneration of sympathetic pathways was not taking place.

This discouraging experience did not dissuade me from advising reexploration of the right and left cervicothoracic fields, for I had had previous experiences in which I had found the sympathetic fibers at the second operation that had been overlooked at the former operation. The very fact that I have never seen recurrence of symptoms in a case of Raynaud's disease or any nonocclusive vasospastic disease of the lower extremity following successful lumbar sympathetic ganglionectomy made me believe that I should accomplish the same results in the treatment of Raynaud's disease of the hands or face if I were able to interrupt successfully all sympathetic pathways carrying vasoconstrictor impulses to the blood vessels of the hands and those that supply the face, brain, and other special organs. I believed that the progressive recurrence of symptoms was not the result of regeneration of new fibers, establishing new synaptic connections in sympathetic ganglions and neurones which were probably injured by retraction, but were not actually divided and removed.

Therefore, in the light of my former experience and my conviction concerning the central influence on vasospasm of peripheral arteries, I advised and performed the fourth sympathetic operation, employing the old cervicothoracic wound and reentering the mediastinum on the right and left sides,[2] respectively. This was done January 4, 1934, in midwinter. The only change I made in the approach was to increase the opening by resecting an additional portion of the first rib in order to have an opening 3 cm. in length extending from the body of the vertebra to the free end of the resected rib. As a rule I never remove the head of the rib which articulates with the body of the vertebra. I leave this small nubbin which measures about 7 mm. in its long axis. By careful dissection, I proceeded with exposure of the respective fields. This exposure allowed me to enter the thoracic cavity from behind through a space between the lower cervical and first thoracic nerves making up the lower trunk of the brachial plexus. On account of the scar tissue, I took special pains in conducting a careful and thorough dissection to avoid injuring or opening the pleura and to avoid injuring the brachial nerves. The first important finding observed on entering into the left cervicothoracic field was that the superior intercostal artery and its accompanying rami had not been divided, and I also found rami ascending from the second and third thoracic ganglions to the lower trunk of the brachial plexus. There also remained some communicating fibers that had circumvented the true cervicothoracic trunk to enter the upper portion of the lower cervical ganglion, which had been resected at the former operation. In order to assure myself still further, I carried out removal of the second thoracic ganglion on the left. The findings on the right side were very similar to those on the left, with the exception that it appeared as if the cervicothoracic trunk had been divided below the lower cervical ganglion. This can easily occur if one attempts to remove the cervicothoracic ganglion by an intrathoracic approach through the second rib. The reverse often takes place; namely, removal of the cervical portion, but overlooking and leaving the thoracic portion of the so-called stellate ganglion when an attempt at removal is carried out through the anterior, so-called Jonnesco approach.[35] There remained, as we suspected, uninterrupted postganglionic rami extending from the third thoracic ganglion to the brachial plexus and fibers accompanying the superior intercostal artery. I expressed the opinion immediately following the operation that I believed that the operation should be successful, and the results should be similar to those accomplished in the feet, for I had removed as far as I could observe every possible postganglionic ramus that could possibly enter the nerves to the brachial plexus.

Fig. 3.—Roentgenogram taken after injection of thorotrast (Nov. 27, 1933), illustrating the incomplete filling of the digital arteries due to vasomotor spasms. These were taken following the two incomplete cervicothoracic operations, just prior to the last thorough and successful cervicothoracic sympathectomy (loaned by E. V. Allen).

Fig. 4.—Roentgenogram taken after injection of thorotrast (Jan. 22, 1934), illustrating the complete filling of the digital arteries to the fingers of the hands following thorough and successful cervicothoracic sympathetic ganglionectomy and trunk resection which has relaxed the vasomotor spasm of the digital arteries (loaned by E. V. Allen).

The wound was closed and the patient returned to her room. Within an hour following the return to her room, the patient was awake and rational and conversed with me when I called on her before leaving the hospital. As I entered the room she extended me her hand and said that her hands now felt like her feet did ever since the first operation. On asking her what sort of feeling this was, she replied that the tightness or drawing sensation had disappeared.

The patient's convalescence was uneventful and postoperative results were extremely satisfactory. Repeated examinations, which have carried her through the spring months of 1934 and the winter and spring months of 1935, have shown that the patient's symptoms in her hands have completely disappeared and have not returned since the last major and complete bilateral cervicothoracic sympathectomy (Fig. 2). The hands are warm, slightly pink, and dry. There has been no return of the symptoms of Raynaud's disease, color changes, pain, or trophic disturbances. She reported that since this last operation she has been able to take part in winter sports, has gone out and deliberately shoveled snow in a snowstorm without any of the untoward results. Thermal studies reveal the continued increased skin temperature. Studies of the capillary loops at the nail folds still show them to be slightly enlarged, but they are much smaller than the dilated loops during the cyanotic stages and only slightly larger than normal capillary loops. The patient has in addition to her vasomotor relaxation a definite bilateral Horner's syndrome, which is not conspicuous when it is bilateral and equal and which does not interfere with her vision. The retinal vessels showed a definite increase in the size or caliber following the successful sympathectomy, suggesting evidence that the postganglionic fibers carrying vasoconstrictor impulses have been interrupted. These fibers are included in the sympathectomy when attempting to denervate thoroughly the blood vessels of the arms and hands. There is present a moderate congestion of the mucous membranes of the nose and throat. The patient is conscious of this and at first thought she was catching a cold, but she was willing to accept the slight discomfort in lieu of the pain and disabling symptoms of Raynaud's disease. The postoperative studies[10] with thorotrast also revealed definite relaxation and an increase in the caliber of the terminal arteries to the digits and to the small arteries of the skin.

The experience encountered in connection with the treatment of Raynaud's disease in the lower and upper extremities suggests that the same disease affects both the upper and lower extremities, that the vasospasm is under a central control, which, if ablated by interrupting sympathetic pathways, will disappear, and that the disappearance of vasospasm results in a cure. This cure is effective only when the operation is extensive and complete and when fibers are not overlooked. Similar operations are indicated in other diseases, such as thromboangiitis obliterans, scleroderma, and rheumatoid arthritis, of the smaller joints, and those of the hands and feet when there exists a definite vasospastic factor and when the vascular study reveals a favorable skin temperature rise on administration of protein.

In studying patients with vasospastic lesions, such as in Raynaud's disease, it is observed that local cold stimuli, immersion of hands in ice water for one minute, will produce the marked color changes of asphyxia followed by cyanosis and rubor. On submitting normal individuals to the same tests, one observes that the blanching is less, that no cyanosis appears, and that only moderate redness follows the return of normal skin temperature. If both individuals are repeatedly sub-

mitted to cold atmospheric temperatures of zero weather, the individual with Raynaud's disease who is suffering with chronic vasospasm will complain bitterly of pain in the fingers and hands and sooner or later develops ulcers on his finger tips, whereas the normal individual would experience but slight discomfort.

Frequently we have seen patients suffering from mild Raynaud's disease improve when they have changed their vocation or worn heavier clothing, such as mittens and overshoes, or moved to a warmer climate. Equally as often we have seen the disease develop in individuals living in extremely hot climates and seen it fail to improve in patients who have moved from colder to warmer climates, which compels us to conclude that the cold temperatures only set up vasomotor reflexes that aggravate existing chronic vasospasm, and that the fault is due to some other cause than a peripheral one in the small arteries. The beneficial effects of changing one's vocation and the amelioration of symptoms which result from the removal of annoying influences connected with the previous vocation or environment suggest that the causative factors may be of a psychic or a constitutional nature. The psychic or emotional influence is borne out still further by observing patients under different degrees of room temperature. The first meeting with the patient in the office where the temperature is 72° F. or warmer, depending on the season of the year, invariably causes the patient's hands or feet to undergo changes in color. Areas on one or more fingers will blanch, become blotchy, and present an area of asphyxia, with an alternating area of cyanosis. The process may shift from finger to finger, or include all the fingers and toes and even a good portion of the hands and feet. Repeated visits result in less emotional strain and in less pronounced changes in color. Excitement, however, and the meeting of new people, cause the symptoms to repeat their cycle.

In our endeavor to relieve these patients of their symptoms, we have performed numerous tests, as have many other investigators, for the purpose of investigating and relieving the phenomena of vasospasm. The injection of a nerve with a local anesthetic agent, as Lewis[43] and Scott and Morton[55] have done, will produce complete vasodilatation of the digital arteries and the smaller arteries of the skin if the peripheral nerve selected carries all of the vasomotor fibers to the digit studied. Otherwise, the vasodilating effects and the thermal skin temperatures will not reveal the true results of nerve block or interruption of all vasoconstrictor impulses to the dermal field under study. An accurate way to determine the effects of a local anesthetic, 1 per cent procaine solution, is to inject a ring of anesthesia about the base of a finger of a patient who is suffering from the typical color changes of Raynaud's disease. One should wait until the fluid has diffused and the finger becomes completely anesthetized before carrying out the tests. In the first place the skin temperature over the tip of the finger will record a

3 to 10° C. rise over the dermal temperatures taken prior to the injection. The skin of this finger will not change color as it does on the other fingers of the same hand when immersed in ice water. It no longer reacts to emotional stimuli like its fellow fingers. Thus it appears that not only the autonomic reflex arc has been broken by the anesthetic, but that the central impulses initiated by psychic factors are also blocked. This suggests that the mechanism of vasospasm of digital arteries and terminal arteries in the skin is not confined to a peculiarity or fault in the artery, but that it is controlled by a central mechanism and is modified by the dermal reflex.

Numerous similar local and general tests have been employed to determine the degree of existing vasospasm and whether it was possible to relieve this vasospasm to justify surgical measures for interrupting the sympathetic pathways. The simplest tests consist of comparing the dermal temperatures over the digits before and after the body has been warmly covered.[19] The increase in skin temperature records in a general way the increased flow of blood to a digit or extremity. The covering tests, however, are not very accurate as they do not always release the psychic factors. Local or regional anesthetic blocks are probably the most accurate tests employed if the investigator makes sure that the dermal area to be studied is thoroughly deprived of all vasoconstrictor impulses without infiltrating that area. Patients dislike multiple injections, however, and this test therefore fails to meet all the demands. The administration of 2 ounces (60 c.c.) of alcohol by mouth produces a sharp vasodilating effect, but it, too, is not as reliable as the effects produced by intravenous injection of a foreign protein. The dose and method used depend on the nature of the substance, the size of the patient, and the reaction desired. An average dose is Lilly's antigen H. or Lederle's triple typhoid vaccine of 25,000,000 to 75,000,000 bacteria. A chill may precede the rise in body temperature, but, if it does, it is of short duration and the investigator will be assured of a maximal rise in temperature within three to four hours after the injection. Again, numerous procedures and devices, such as oscillometry, calorimetric studies, observation of blood flow in the capillaries in the nail fold, and temperature studies of the skin over the various digits are employed to calculate the changes in blood flow produced by induced fever. As previously stated, the fever is a manifestation of increased metabolism. The increased metabolism results in heat production. Thus, the heat-regulating mechanism through its plexiform arrangement in the medulla proceeds to disperse the increased body heat by dilating peripheral arteries, which permits the blood to reach the surface and to become cooled.

By studying the effects of fever on a patient with Raynaud's disease, it is observed that, during the height of fever, none of the fingers or toes are capable of going through the cycle of color changes when im-

mersed in ice water or exposed to cool atmospheric temperatures. It is also observed that the psychic influence producing changes in color has also been lost during the height of fever. The fever reaction, however, must be a brisk one of at least a rise in temperature of 3 to 4° C., by mouth, in order to produce a thorough vasodilating effect.

The vasodilatation effect relieves the patient of all symptoms. Surgeons have therefore tried to reproduce these same effects. We have learned that if it were possible to raise the skin temperature of the affected digits to a degree at least twice as high as the rise of the mouth temperature, by the administration of protein, we could expect the same symptomatic relief as is obtained by the fever test or vaccine treatment.

CHOICE OF OPERATIVE MEASURES

I hope it is clearly understood that I never advise or perform sympathectomy in a case in which the disease is mild or is readily controlled by medical management. It is performed only when the disease is progressing in spite of medical measures, and when the vasodilating tests, preferably the fever tests, indicate a favorable dermal rise in temperature, on the theory that the increased skin temperature is a definite expression of increased blood flow due to vasodilatation from relaxation of arterial spasm.

The earlier investigators attempted to produce the vasodilating effects by periarterial sympathectomy. The operative results were incomplete, but the conception propounded by Leriche and Fontaine[42] of paralyzing the vasomotor control to peripheral arteries has been repeatedly verified. Royle's[54] ramisection represents another step in the surgical development. Though his operation was more extensive in scope than periarterial sympathectomy, it did not originally include sufficient rami to denervate thoroughly the vessels to an extremity. It was for that reason that I suggested and performed extensive forms of sympathetic ganglionectomy and trunk resection with the hope of thoroughly interrupting the impulses of vasoconstriction.

The bilateral lumbar sympathetic ganglionectomy which includes the second, third, and fourth lumbar ganglions on both sides, with the intervening trunks, interrupts all vasoconstrictor impulses leaving the lower end of the thoracolumbar outflow to the feet and lower part of the legs.[34] Simple division of the lumbar sympathetic trunk below the second lumbar ganglion would be sufficient if the distribution of fibers were constant, but since some may descend from higher ganglions and escape the trunk below the second ganglion, it becomes necessary to carry out more extensive operation to interrupt thoroughly postganglionic rami carrying vasoconstrictor impulses.

In nonocclusive diseases like Raynaud's disease, the skin temperature promptly increases following sympathectomy. The rise immediately

after operation is as high as that produced by fever from administration of protein. In two or three days it falls, with the cessation of postoperative fever, to a level of 1° to 3° C. below the high point during the fever studies. It remains there indefinitely, for Brown and his staff have rechecked these patients again and again at varying intervals following operation. Environmental temperatures influence the sympathectomized area less than they do normal skin, but, to assure constant readings, an air-conditioned room is necessary for temperature studies. We also prefer to use an electrothermocouple, with numerous electrodes, which can be taped to the finger tips and to other areas of skin without moving or disturbing them throughout the test. These readings not only give information concerning the general vasodilating effects, but indicate the status of individual digits. In cases in which the skin temperature fails to rise under fever studies, it will likewise fail to rise following sympathectomy and the patients will fail to receive the beneficial effects of the operation.

Postoperative observation of the feet reveals that the skin is much warmer than that of the nonsympathectomized area over the hands. It is dry and does not sweat since the sympathetic fibers to the sebaceous and sweat glands have also been divided in the lumbar sympathectomy as they intermingle, and they are so closely associated with those carrying vasomotor impulses that it is impossible to separate them. The skin is slightly pinker in color than normal skin. Microscopic observation of the capillary loops at the nail folds reveals that the loops that were dilated before operation have returned to normal size and that the corpuscles are passing through at a greater rate of speed than they did when the skin was in the state of asphyxia or cyanosis. Prolonged and marked cyanosis results in some permanent change in the capillary loops. In those instances they will contract some, but are unable to return to normal size, which explains the phenomenon of the appearance in a few cases of bright red finger tips following sympathectomy.

The four most interesting observations following sympathectomy are: (1) failure of the skin to undergo changes in color during exposure to ice water or to cool temperatures, (2) its failure to repeat color changes when the patient becomes excited or is under emotional stress, (3) relief of local pain and recovery of trophic changes, and (4) the measurements of retinal arteries and veins before and after successful cervicothoracic sympathetic ganglionectomy and trunk resection reveal an actual increase in diameter, following the operation, of one-fourth to one-half of that of a normal vessel. Following successful cervicothoracic sympathectomy, the patients are no longer able to blush when embarrassed, which phenomenon suggests one of several possibilities: first, the lack of a definite vasodilating mechanism; second, the absence of antidromic vasodilator fibers in the sensory peripheral spinal nerve, and third, that fibers carrying vasodilator impulses travel with those that carry vaso-

constrictor impulses and consequently have been divided. I am inclined to believe that the vasodilating mechanism is one of inhibition of the autonomic centers, a phenomenon we reproduce by sectioning sympathetic pathways in interrupting vasoconstrictor impulses to the arteries, capillaries, and veins. I believe these postoperative observations support most strongly the theory that exaggerated vasospasm, vasospasm of such a character as to interfere with the blood supply of tissues, is a fault of the central mechanism, and that the postganglionic rami convey such vasoconstrictor impulses to all arteries, but that disease results only when the smaller arteries are affected.

This opinion is further supported by experiences observed in connection with the development of operations on the sympathetic nerves to the vessels of the upper extremities. Several of the earlier operations were incomplete and, consequently, the results were incomplete. At that time this suggested that perhaps Raynaud's disease of the hands was different from that of the feet. As I changed the operative approaches and increased the scope of the surgical field to assure complete interruption of all sympathetic rami carrying vasoconstrictor impulses to the vessels of the hands, the same satisfactory results obtained following lumbar sympathectomy were reproduced in the hands. The real test came, however, when I operated again in those cases in which I and others had failed to give complete relief by incomplete sympathectomy. The case reported, with its multiple operations, is one of several which supplies the evidence that if the surgeon overlooks fibers or carries out a limited operation on the cervicothoracic ganglions, trunks, and rami, incomplete results will follow, and that complete extensive operations will give satisfactory results. I have had failures following cervicothoracic sympathectomy, but they have not occurred of late when I have done a complete operation unless there was an advanced coexisting scleroderma or extensive trophic changes. These trophic changes produce strangulation and thrombosis of the distal portions of the smaller arteries, to such an extent that vasodilating procedures are ineffective since the few remaining arteries are either unable to dilate or are too few in number to increase the blood supply sufficiently to bring about restitution of the tissues. In the earlier phases of this type of surgery we had to learn by trial and error, but today we rely on vasomotor studies, as we learned that those who respond favorably to fever therapy will respond favorably to properly planned and executed forms of sympathectomy.

ESSENTIAL HYPERHIDROSIS

Of interest is that small group of individuals who have such excessive perspiration of the hands, and occasionally of the arms, face, and feet, that it interferes with their economic and social existence. It prevents them from working on books and from handling fine fabrics, and

also ruins their clothing, gloves and shoes. Those who are more timid are constantly embarrassed in meeting strangers or in associating with the opposite sex since their hands are always dripping wet. Inasmuch as the sudomotor fibers were included in the various types of sympathectomy designed to relieve vasomotor spasm, it became apparent that the same operation could be employed to correct hyperhidrosis. The result is extremely satisfactory since the skin promptly becomes dry and remains so permanently. Excessive perspiration accompanies vasomotor reactions which manifest themselves in cool or hot, wet hands. At no time have the color phases become as marked as to resemble true Raynaud's disease. However, excessive moisture on the skin is frequently present with symptoms of Raynaud's disease, but it is never so excessive that it drips from the fingers or toes as it does in essential hyperhidrosis.

An unusual observation is that perspiration will be increased over the trunk (the chest, back, and abdomen) following bilateral cervicothoracic sympathectomy, and especially so if the patient has also undergone bilateral lumbar sympathectomy, regardless of the disease for which these operations were performed. The increase of perspiration in nonsympathectomized areas appears to be a compensating phenomenon of the heat-regulating mechanism, signifying a central control of the sudomotor fibers.

Clinically, this excessive perspiration about the chest is cared for by encouraging the patients to wear a sleeveless silk and wool undershirt, which is changed daily. This wool garment absorbs the perspiration and does not produce the cold and wet sensations that cotton or silk garments do.

ESSENTIAL HYPERTENSION

In our surgical attack on essential hypertension I have employed two somewhat different but extensive forms of sympathectomy. The rationale of such operations[7, 23, 47, 49] is to remove the vasomotor control from a large vascular bed, thus creating a reservoir in the denervated vessels when the nonsympathectomized vessels go into spasm[20] likewise support the theory of central control. The suprarenal gland is likewise thoroughly denervated, since its innervation is interrupted at its source. The one operation consists of bilateral ventral root rhizotomy,[45] from the sixth thoracic to the second lumbar vertebrae, inclusive. The operation has been effective in controlling and in relieving the symptoms of essential hypertension in younger individuals in whom there has been no permanent damage to the cardiovascular-renal systems. This procedure is distinctly a major operation and one that does not allow exploration of the suprarenal glands. I have therefore devised a second operation, which is as effective as the first and also permits exploration and resection of the suprarenal glands. The operation is divided into

two stages, and there are two separate incisions. It consists of subdiaphragmatic, retroperitoneal exposure and resection of all splanchnic trunks as they perforate the diaphragm to enter the abdominal cavity, and removal of the first and second lumbar sympathetic ganglions to interrupt thoroughly the last two white rami of the thoracolumbar outflow and to permit exploration or resection of the suprarenal gland.[25] At this later operation all sympathetic rami below the diaphragm are sectioned except for an occasional fiber that follows the aorta through the diaphragm. It permits thorough denervation of the suprarenal gland by sectioning the rami at their source before entering the capsule.

The clinicophysiologic observations[33] following these two extensive forms of sympathectomy are very similar. The patients are relieved of headache and precordial distress. They feel more comfortable; however, they have lost some of their drive or endurance. Their blood pressure, immediately following operation, will often drop as much as 100 mm. Hg under the preoperative readings, but as the patients convalesce and are able to be up and about, it gradually rises to a constant mean curve which has a systolic drop of 44 mm. and a diastolic drop of 38 mm. Following rhizotomy, the abdominal muscles are paralyzed. This accounts for the sagging of abdominal muscles which has to be corrected by an abdominal binder. In some instances the systolic blood pressure has dropped below 100 mm. when the abdominal binder was removed and the patient was in the upright position. These extensive forms of sympathectomy result in vasodilatation and in increased skin temperatures of the feet, legs, and body below a transverse line placed midway between the ensiform cartilage and umbilicus. The cessation of sweating begins at the same line and extends to the feet. The urogenital mechanism of ejaculation is lost, but the libido and potentia are preserved in males. These is no pathologic disturbance in the retention or evacuation of urinary or fecal contents. However, in light of our experiences with the treatment of Hirschsprung's disease and cord bladder, I would be inclined to expect evacuations to be more frequent after operation than they were before. The operation has not disturbed the menstrual cycle. None of the females has desired pregnancy so I am unable to state whether or not the operation would interfere with a normal one. I am inclined to think it would not, since the effect is similar to presacral neurectomy, which has not prevented nor disturbed normal pregnancy. Men, of course, become sterile unless there should be a spontaneous seepage of seminal fluid, since there is no ejaculation with the orgasm.

CONGENITAL MEGACOLON AND BLADDER PARALYSIS

The factors producing, and the results obtained by sympathectomy in the treatment of, congenital megacolon,[3, 36, 51, 56] congenital bladder paralysis and paralysis of the bladder resulting from injury to the

sacral center of the spinal cord or fibers making up the parasympathetic nervous system, support the theory that a central mechanism controls and coordinates the antagonistic forces of retention and evacuation of urinary and fecal contents. The sympathetic nervous system supplies the inhibitory stimuli of retention by inhibiting the detrusor muscle of the bladder[27, 41] and the musculature of the descending colon and rectum and by supplying motor stimuli of contraction to the internal sphincters of the bladder and rectum. The parasympathetic system, through the second, third, and fourth visceral sacral nerves, supplies the reciprocal antagonistic innervation, that of motor contraction of the detrusor muscle and musculature of the lower descending colon and rectum with inhibitory stimuli to the internal sphincters of the bladder and rectum. The sympathetic fibers further innervate the lower portion of the ureters and sphincters and smooth musculature of the mechanism of ejaculation in males in the urogenital trigone.

Musculature imbalances should result from both increased or decreased stimuli of either nervous system. The fault therefore might be due to one of two causes: first, because the stimuli of retention overpowered those of evacuation, and second, because stimuli of evacuation were fewer and of less force than those of retention. Congenital megacolon apparently results from excessive stimuli through the sympathetic nervous system rather than to diminished stimuli in the parasympathetic system, for the symptoms of excessive fecal retention can be controlled and relieved by properly planned sympathetic operations which reduce the number of incoming stimuli. We have observed that the operations which have proved most effective in the treatment of Hirschsprung's disease are not the small, limited types of sympathectomy but are those that include most or all the fibers to the lower portion of the descending colon and sphincter of the anus. Such procedures may vary from bilateral lumbar sympathectomy, including the second, third, and fourth lumbar ganglions, or presacral nerve resection[8] with division of the inferior mesenteric nerves, to a combination of bilateral lumbar sympathectomy with presacral resection as performed by me, or a combination of bilateral lumbar sympathectomy with presacral neurectomy and division of the sympathetic fibers accompanying the interior mesenteric artery, as employed by Craig and me.

Myelodysplasia of the sacral cord, traumatic myelitis of the lower thoracic or sacral cord, spina bifida occulta, and intraspinal tumors in the same area can readily impair the parasympathetic spinal center or the fiber tracts carrying parasympathetic impulses. When this occurs, it is apparent that the evacuating force of both urinary and fecal functions will be reduced or be overpowered by what may be a normal retaining force. It is, therefore, in such cases that the surgeon attempts to reduce stimuli by sectioning sympathetic pathways that carry impulses of retention, in order that the weakened force of evacuation will be able to

reciprocate with that of retention. Excessive parasympathetic stimuli or decreased sympathetic stimuli should produce the opposite effects of Hirschsprung's disease and cord bladder. Clinical investigations, however, have not verified these facts, nor have the surgeons contributed definite evidence in the treatment of chronic noninfectious diarrheas or spastic colitis.

I believe that all these observations support the theory that autonomic dysfunctions may be initiated in the cerebral centers, and that pathologic stimuli are transmitted over tracts, ganglions, and rami to the visceral organs and somatic segments.

One could go on at length discussing the factors responsible for the numerous and individual diseases. I believe, however, the recorded observations justify the surgeon to employ properly planned sympathectomies in selected cases for the purpose of removing excessive autonomic stimuli in order to balance reciprocal involuntary functions.

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Editorials

Irradiation and Surgery in Treatment of Cancer of the Breast

THERE are many controversial questions concerning the relative importance of irradiation and of surgery in the treatment of cancer of the breast. However, one fact seems to be definitely determined, after years of discussion, and that is that no form of irradiation has a replacement value to surgery except as a palliative measure in the hopelessly inoperable cases and for the treatment of local recurrences.

Irradiation has also very definitely demonstrated that by its employment, local recurrences have been markedly reduced. However, this reduction in the percentage of local recurrences is no excuse for dereliction on the part of the surgeon in not performing as complete and as radical eradication of the malignancy as it is possible to do by a "block dissection" carried as far as anatomic limitations will permit. The preoperative employment of irradiation is, perhaps, of greater value than postoperative irradiation. However, preoperative irradiation carries with it certain dangers, one of which is the failure of the patient to return on a specified date for the operation. Patients sometimes delay their returning because, at first, their local condition has improved. They then further delay their return, still hoping for a continuation of their improvement, but unfortunately, until a time when the cancer has extended beyond the reach of surgery and irradiation. This is, of course, a defect in the "follow-up" system, and not of the preoperative irradiation, but is mentioned as a warning to others not to allow a similar calamity to occur in their practice.

After the proper preoperative irradiation has been completed, an operation of the Halsted type should be done. For many years we have made a practice of washing out the operative field with hot normal saline solution. The solution is just about as hot as the hand can comfortably stand without burning. The field of operation is "flushed out" so as to wash out any small clots of blood or possible malignant cells that might be present. In addition to this, it is conceivable that the heat might kill some cancer cells if any happen to have been "squeezed out" during the dissection. Gentle handling of the breast is essential to prevent such a "squeezing out" accident. Such cancer cells have very little resistance to even a moderately high degree of heat.

Before the flaps of skin are closed, radium element, properly screened, is placed around the field of operation, especially in the region of the

internal mammary vessels and in the axilla. Irradiation given in this manner is certainly more effective than where the filtration effects of skin have to be surmounted.

We have had no cases of pneumonitis resulting from this method of radium irradiation.

We have not been able to demonstrate that there is any interference with wound healing.

We feel that the very occasional occurrence of swelling of the arm following such radical operations and irradiation is due to a low grade infection in the axilla preventing the redevelopment of lymphatics, rather than in any way connected with the irradiation. In fact, our percentage of such occurrences is less than before we started irradiation.

The free and early use of the arm has contributed much to the comfort of the patient, and, perhaps, by muscular contraction has stimulated regeneration of the lymphatics.

The postoperative irradiation is started in about ten days, and great care is taken to be certain that the radiologist realizes the danger inherent to the employment of the high voltage machines now in use. I am confident that with the advent of so many high voltage machines, there will probably be an increase in the percentage of cases of extensive burns and pneumonitis. Surgeons should cooperate with the radiologists in trying to prevent such a situation from occurring.

If the patient has not passed the menopause, sterilization is done by irradiation of the pelvis. If there is any doubt concerning the propriety of this procedure, one can be convinced easily by a visit to the Memorial Hospital in New York. There he will see roentgenograms of two cases with the thorax filled with metastases (or something that looks like such) following cases of carcinoma of the breast. In these two cases, these shadows in the lungs have disappeared after irradiation of the ovaries. For some years we have noticed an apparent decrease in the size of inoperable cancers in the breast after irradiating metastatic involvements in the pelvis, and perhaps this is the result of some action of the x-rays on the ovaries, with the subsequent development of defensive hormones.

There is a very hopeful field of investigation in the prophylaxis of cancer of the breast by the proper correction of pelvic disorders and effective support of the breast, as well as a study of the hormones. A consideration of such fields leads beyond the scope of this editorial.

We have never seen a case of a true metastasis "cured" by irradiation. We have all seen many cases, however, in which the pain has been greatly relieved by irradiation.

I think we can correctly conclude that there is no conflict between irradiation and surgery. Further, that the chief hope of a cure of can-

cer of the breast is still dependent on the radical operation, but that irradiation is an added safeguard when administered properly and in intelligent hands.

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Congenital Obstruction of the Small Intestine

ONLY a few years ago, pediatricians and surgeons expressed little hope of a successful outcome in any except isolated cases of congenital intestinal obstruction, but recently evidences of improvement in the management of acutely ill infants have multiplied, and it seems established that the mortality rate in these small patients need be very little greater than in older children and adults if the proper precautions are taken.

The transition from the older pessimism to the newer optimism is encompassed in a report by Ladd[1] on the cases of congenital obstruction of the small intestine which occurred in the Children's Hospital in Boston over a period of years up to 1933. Up to the time of Ladd's article there were only twenty-nine cases reported—from a literature replete with autopsy descriptions and operative failures—in which recovery had occurred following operations for malrotation, atresia, or stenosis of the small bowel in infants and children up to the age of twelve years. In Ladd's series there were sixty cases with seventeen survivals.

No more eloquent evidence of this advance in pediatric and surgical technic has been forthcoming than the recent report by Morton and Jones[2] of eleven consecutive successful operations on newborn infants with congenital obstruction of the duodenum or jejunum.

The babies all had anomalies which, from the day of birth, upset their caloric, water, and salt balance in various degrees. The pediatricians were alert. The early vomiting of congenital obstruction was distinguished from that of pyloric stenosis, which almost always comes on after a normal period of two weeks or more. The necessity for surgical intervention was recognized promptly. By judicious use of roentgenographic studies with barium, accurate diagnoses were made, and by intelligent administration of blood, dextrose and other fluids, the infants were brought to a near physiologic normal and were ready for operation. The technic used would have delighted Halsted. Unhurried gentleness (made possible by skillfully administered ether anesthesia, just heavy enough to allow relaxation), retention of body heat, careful hemostasis, and anatomic suturing of intestinal and abdominal layers with fine interrupted silk brought the babies from the operating table in a condition nearly as good as at the start of the procedures. Feedings were begun almost immediately and care was taken to provide for

caloric, salt, and fluid needs as before operation. All of the wounds healed without infection or rupture: a tribute to asepsis, the method of suturing, and the physiologic state of the infants' tissues.

Every physician whose infant patient has been operated upon for a gastrointestinal obstruction will realize the significance of a record of eleven such cases. This is not luck, but the result of years of development in pediatric and surgical care. And, after all, there is nothing excessively difficult in the technic and the principles underlying it. Morton[3] has discussed them in detail in a previous article devoted to surgery in infancy and in old age.

The surgeon who operates successfully on sick infants is forced to adhere to a program which is physiologically and surgically nearly perfect. It is not out of place to suggest that the surgeon who operates on adults can use these principles to the great advantage of his patients, particularly those whose margins of safety are narrow, as they are in infancy.

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Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

RECENT ADVANCES IN SURGERY FROM A BACTERIOLOGIC VIEWPOINT

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AIR-BORNE CONTAMINATION OF OPERATIVE WOUNDS

RECENT years have seen the revival of interest in the air as a source of wound contamination, all but forgotten since the days of Lister. Meleney[1] from a study of the bacterial content in the air of his operating rooms has estimated that between 35,000 and 60,000 bacteria fall upon the sterile operative field during the course of one hour. Similar observations have been made in the operating room by Truesdale,[2] Davis,[3] Hart,[4] Gudin,[5] Hunt,[6] and Brewer.[7] White[8] has found the hemolytic streptococci abundantly present in the air of rooms occupied by patients with streptococcus puerperal sepsis, and Cruickshank[9] has found the same organisms present in the air about patients with burns infected with the streptococcus. Meleney and Stevens[10] traced an epidemic of wound infections with the hemolytic streptococcus to the noses and throats of the operating room personnel. Hart[4] demonstrated that the incidence of postoperative wound infections with the hemolytic *Staphylococcus aureus* was seasonal and varied according to the presence of these organisms in the air of the operating room and in the noses and throats of the operating room personnel.

Adequate masking, eliminating currents of air, frequent mopping of operating room walls and floor, elimination of overhead fixtures which may trap dust, complete change of street apparel before entering the operating room suite, and employment of canopies[2] to cover instrument tables have been advocated to prevent air-borne contamination of the operative field.

The ineffectiveness of the ordinary surgical mask has been demonstrated by Walker,[11] Blatt and Dale,[12] and Waters[13] and has led to the incorporation of an impervious material (cellophane) into the mask to increase its effectiveness.[12, 13] Walker[14] states that an analysis of sixty masks submitted from hospitals throughout the United States showed none to be effective under all conditions for which a mask might be called into service and concluded that the ideal surgical mask has not yet been perfected.

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Sterilization of the air in the operating room has been attempted as the most logical solution to the problem of air-borne wound contamination by Gudin[5] in Rio de Janeiro and Hart[4] in this country.

Gudin[5] has attempted sterilization of the air in the operating room with formaldehyde. The operating room is sealed, and formaldehyde is blown into the room. The formaldehyde is then neutralized with ammonia. Finally, the air is filtered through a solution of tartaric acid which removes the product of the combination of formaldehyde and ammonia (urotropin) and the excess ammonia. Surgeon and patient pass through two or three air-tight sterilized compartments before entering the operating room. In their hands, a noteworthy diminution of infection in clean operative wounds was noted. Theoretically, it would appear that the method, though laborious, would be effective in the presence of adequate masking of the mouth and nose.

In the absence of an ideal surgical mask, Hart turned, in 1934, to the use of radiant energy as the most logical method of continuous sterilization of the air in the operating room. The radiant energy is supplied by a battery of tubes suspended over the operating table producing radiations in the ultraviolet spectrum of the most effective bactericidal wave lengths. Radiation is used constantly before and during the course of the operation. He found that such a battery of radiation destroyed in 60 seconds the hemolytic *Staphylococcus aureus* when lightly sprayed on an agar plate and placed within a radius of five feet of the source of radiation. Agar plates exposed in the unradiated operating room often picked up as many as 150 bacteria in one hour's time, while plates exposed within 6 to 8 feet of the radiation tubes during operation in the presence of the radiation showed a 95 per cent reduction of this contamination. Working under this radiation it is necessary for the operating room staff to protect their eyes and skin from the effect of the radiations. Clinically, in eighteen thoracoplasties performed under the bactericidal radiation, Hart[4] found that none of the wounds became infected, that the postoperative temperature elevation was lower and of shorter duration, and that there was less postoperative discomfort in the wound, more rapid wound healing, and quicker return to the preoperative general condition. More recently[15] he has reported a series of 218 cases including herniotomies, thyroidectomies, thoracoplasties, and radical mastectomies with similar results, and concludes that continuous radiation of the operating room represents the only means now at hand to obtain and maintain sterility of the air in the operating room.

TREATMENT OF STAPHYLOCOCCUS INFECTIONS

The demonstration that the staphylococcus produces a hemolytic, leucocidal, and necrotizing exotoxin which is highly antigenic and to which active and passive immunity can be developed in man has revolutionized our concept of staphylococcus infections. During the past six

years, mainly as a result of the work of Parker,[16] Burnet,[17] and Dolman,[18] it has been demonstrated that most strains of staphylococci under appropriate conditions produce active exotoxins. This toxin has been shown to be the cause of the main features of the lesions in all types of staphylococcus infection. From the pooled toxins of various potent strains of staphylococci, an innocuous antigen has been obtained by incubating with formaldehyde. This formalized toxin (staphylococcus toxoid) has proved a valuable antigen for use in active immunization of patients with minor staphylococcus infections and for the production of an antitoxic serum for patients with severe infections, notably those in which a staphylococcus bacteriemia is present.

Staphylococcus toxoid has been used to induce active immunization in minor staphylococcus infections by numerous authors.[19] Recurrent furunculosis, chronic osteomyelitis, acne vulgaris, staphylococcus infections of nose, throat, and sinuses, recurrent abscesses, carbuncles, recurrent styes, staphylococcal pyelonephritis, blepharitis, and pyelitis represent some of the conditions for which it has been used. Three reports are unfavorable[19 b, f, and m] and are explained by Dolman[20] on the lack of specificity and potency of the strains of staphylococcus used in preparing toxoid by these authors. All of the other reports are favorable. The best results have been obtained in the treatment of recurrent furunculosis and the least favorable in acne. In all cases, the antitoxic titer of the patient's serum rose during the course of treatment, occasionally as high as twenty times the original level.[19 e]

The duration of immunity thus produced is not known. In Dolman's series of eighty-one cases treated for furunculosis, only three had recurrences within two years; and in all of these, the antitoxic titer had by this time fallen to its previous level. He showed that the antitoxic titer of patients with recurring furunculosis before treatment is started is usually within normal limits. Thus, no marked increase in circulating antitoxin appears as a rule to be provoked by a series of boils. This he found characteristic of all superficial infections and was in contrast to the response of deep-seated infections, notably chronic osteomyelitis, where the antitoxic titer was uniformly high. In the latter, however, a five- or tenfold increase in the antitoxic titer could usually be induced by injections of staphylococcus toxoid and was followed by favorable clinical results: the general health improved; sinuses occasionally closed; and appetite and sense of well-being improved.

Smith[21] has recently introduced the theory of hypersensitivity to the staphylococcus toxin as being an important factor in staphylococcus infections. In certain patients, he finds hypersensitivity to skin doses of staphylococcus toxoid in dilutions as high as 1:100,000 and feels that this hypersensitivity is responsible in a large measure for the clinical evidence of staphylococcus infection. In such patients, he desensitizes as well as actively immunizes by injecting subcutaneously gradually in-

creasing doses of toxoid beginning at the highest dilution to which the patient is sensitive and carrying him through the strongest dilution. For routine skin testing a dilution of 1-100 is employed.

For the treatment of severe staphylococcus infections with or without a demonstrable bacteriemia, staphylococcus antitoxin has been prepared from the serum of hyperimmunized horses and used with encouraging results by Dolman,[22] Gross,[23] Panton, Valentine, and Dix,[24] Parish and Clark,[25] and Joyner and Smith.[26]

Dolman,[22] working with a staphylococcus antitoxin prepared by the Connaught Laboratories at the University of Toronto, has had the largest experience with the treatment of severe staphylococcus infections with antitoxin. In a series of 104 patients so treated, 24 with various types of staphylococcus infection of skin and subcutaneous tissues all made remarkably rapid recoveries after the administration of antitoxin. In 32 severe cases of staphylococcemia secondary to osteomyelitis in children, 22 recovered. Of 22 apparently hopeless cases of staphylococcemia in adults, five recovered. He concluded that the antitoxin offered the most hopeful and reasonable type of specific treatment at present available for acute staphylococcus infections and toxemias. Gross[23] states that the use of antitoxic serum is of prime importance in staphylococcus septicemia as well as in severe cases of osteomyelitis, furuncles, and carbuncles where symptoms of toxemia are marked. Panton, Valentine, and Dix[24] report 13 cases treated with antitoxin prepared by the Lister Institute. In 5 cases of carbuncle, the results were indefinite. In 3 cases of fulminating septicemia, the use of serum did not influence the course of the disease. In 5 cases of pyemia, a general improvement and cessation of further metastatic abscesses followed administration of the serum. Parish and Clark[25] allude briefly to the clinical usefulness of antitoxic serum, stating that results were encouraging in all cases.

Joyner and Smith[26] have reported the only series of cases treated with staphylococcus antitoxin in this country. They used a refined and concentrated antitoxin prepared by the Lederle Laboratories and now marketed commercially by this company. In 11 of 13 children with acute osteomyelitis with staphylococcemia, a marked improvement in the general condition, subsidence of clinical evidence of toxemia and recovery followed the administration of staphylococcus antitoxin and prompt surgical drainage of the original focus. They demonstrated that the administration of antitoxin shifted the blood picture in the Schilling hemogram and was attended in all 11 cases by a decrease in the percentage of nonsegmented and an increase in the percentage of segmented polymorphonuclear leucocytes.

All who have worked with the staphylococcus antitoxin emphasize that the employment of the serum presents certain difficulties characteristic of serum therapy in general, in addition to those inherent in the case to be treated. The antitoxin is not directly bactericidal but has

an indirect bactericidal action by neutralizing the circulating toxin and thus removing the inhibition of normal bactericidal activity of the blood. It cannot undo damage already suffered by organs or tissues, but it is able to protect from further damage and also to prevent fresh localizations. Free and adequate drainage of localizations of pus remains essential in every case and serum therapy can be regarded only as an adjunct to the recognized and well-established principles of surgical treatment of staphylococcus infections.

ACTIVE IMMUNIZATION AGAINST TETANUS

Because of numerous examples illustrating the inadequacy of passive immunization against tetanus during the World War and the danger of serum reactions, or of inducing hypersensitivity to horse serum in individuals in whom subsequent serum therapy for other conditions may become necessary, active immunization against tetanus has been attempted and is now being carried out successfully.

In 1925, Ramon[27, 28] prepared a tetanus toxoid for active immunization against tetanus using the same method of detoxification that he had previously proposed for the diphtheria toxin. Ramon and Zoeller,[29] and others[30] then injected several hundred subjects with their formalized toxin (toxoid), giving three injections at one-month and two-week intervals. A further injection given one or two years later resulted in a great increase in the antitoxic titer of the serum of these individuals. Their results were confirmed by Sacquépée,[31] Lincoln and Greenwald,[32] and Sneath.[33] Sneath found that after the first series of three injections of tetanus toxoid given at four- and two-week intervals to 29 individuals, significant amounts of antitoxin developed in 28 patients, and in 20, a quantity of antitoxin (0.1 unit or more per cubic centimeter) sufficient to provide effective protection against tetanus had developed. Sneath and Kerslake[34] in a study of this group twelve to fifteen months later found that only three still possessed a protective concentration of antitoxin. At this time, a single additional injection was given to 14 of the series, several of whom had not produced a protective amount of antitoxin after the first series of injections. Thirteen of these 14 persons had developed a protective concentration of antitoxin by the seventh day after injection, the average being much higher than at the close of the first series. This protective concentration was maintained in all of the thirteen subjects for at least one month.

These findings confirm those of Ramon and Zoeller and form the basis for the present method of immunization. Three injections of tetanus toxoid are given at intervals of four and two weeks. Thereafter, a single injection of toxoid, instead of the usual prophylactic dose of antitoxin, is given at the time of injury. This last dose quickly raises the immunity to a higher level and protects the patient against infection. There is reason to believe, because of the duration of immunity thus

developed, that in persons frequently injured, a dose of toxoid given annually would probably give ample protection. This procedure is recommended for the immunization of persons engaged in activities which submit them to frequent injuries and is now obligatory for every soldier in the French Army.[35]

CHEMOTHERAPY OF BACTERIAL DISEASES

Although brilliant results have been obtained in the management of protozoan and spirochetal infections by chemotherapy, the treatment of bacterial infections by drugs has until recent years been uniformly unsuccessful. In 1935, Domagk[36] observed the selective chemotherapeutic action in streptococcus sepsis in mice of an azo dye containing sulphonamide. Working with Mietzsch and Klarer, he prepared numerous similar compounds whose effect on streptococcus infections excelled all those previously observed in animal experiments. He injected a virulent strain of hemolytic streptococci of human origin into the peritoneal cavities of twenty-six mice. An hour and a half later, twelve received by stomach tube some of this dye. All of the untreated mice died in three or four days. All of the mice receiving the dye survived. Some of the treated mice received only 0.02 mg. of the drug, an amount 100 times less than the maximum tolerated dose. The drug —the hydrochloride of 4 sulphamido-2, 4-diaminoazobenzol—Domagk named "prontosil."

Levaditi and Vaisman[37] using a similar compound synthesized by Girard obtained somewhat similar though less striking results in the treatment of streptococcus sepsis in mice. Nitti and Bovet,[38] and Colebrook and Kenny[39] found similar results in the treatment of mice with streptococcus infections of high virulence, although a single oral dose was not sufficient to protect mice inoculated with streptococci of low mouse virulence freshly obtained from human infections.

Clinically, Colebrook and Kenny have reported the best controlled series of cases treated with prontosil, although there are numerous clinical reports in the German literature[40] unanimously favorable to its use. They treated 38 patients with hemolytic streptococcus puerperal infection with oral and intravenous or intramuscular doses of prontosil. In 16 of these cases, they feel that recovery probably would have resulted with or without prontosil, and no conclusions could be drawn. In 17 cases with severe infections, a prompt clinical improvement and remission of fever followed the first few doses. In 3 of these cases, there was evidence of infection of the general peritoneal cavity, and in 5 others, of a beginning of such spread. In all these patients, such signs quickly disappeared after treatment. Three patients with overwhelming infections died, while in one case, treatment seemed to have no effect and in another, it was thought that the treatment aggravated a pyelitis and was stopped. In the 38 patients with puerperal sepsis treated immedi-

ately preceding the use of prontosil, 10 died, with a mortality of 26.3 per cent. In the next 38 cases treated with prontosil, only 3, or 8 per cent, died.

Although prontosil was originally observed to have a selective activity in streptococcus infections, Horlein[41] reports it to effect cures in rabbits with staphylococcus infections. He has also found it particularly effective in the treatment of infections with the pneumococcus type III. Beneficial effect in other types of bacterial infection has not been demonstrated. Prontosil is not bactericidal in vitro, and its manner of action in the animal body is not understood at present.

TREATMENT OF INFECTED WOUNDS

Search continues for an ideal dressing to encourage healing in infected wounds, burns, and indolent ulcers. However, such fundamental principles as free and adequate drainage, specific treatment directed toward the underlying cause of the ulcer or infection, and a rational regime to improve local tissue resistance remain of first importance in the treatment of these conditions.

Cod liver oil applied locally in the treatment of burns and suppurating wounds has received much recent attention, notably from Loehr[42] in Germany who was its first proponent. He uses raw cod liver oil or a cod liver oil ointment applied locally to many types of fresh and infected wounds, as well as on fresh and old burns. He feels that cod liver oil inhibits bacterial growth, produces a healthy granulation tissue, stimulates epithelization, and allays pain. The effectiveness of cod liver oil he attributes to the presence of its vitamins and not to its oil. Similar results have been obtained by Steel,[43] Tennent,[44] Tumansky and Yatsevich,[45] and Iost and Kochergin,[46] while Buchheister[47] combines honey and cod liver oil with equally satisfactory results.

Tumansky and Yatsevich found that on being placed in cod liver oil the growth of streptococci ceased in one hour and staphylococci in six hours. The addition of petrolatum decreased this bactericidal property. Padula,[48] observing the effect of the local application of vitamins to wounds in experimental animals, found that vitamin D favored healing in animals on a normal or low vitamin diet, vitamins B and C favored healing only when the animals were on a low vitamin diet, while vitamin A retarded healing in animals on a low vitamin diet and did not affect healing in those with a normal diet. Holtzinger,[49] studying the effect of vitamins on bacterial growth, found that vitamin D increased the luxuriance, while vitamin A inhibited growth.

Ultraviolet irradiated petrolatum has been used locally in various forms of wounds and infected sinuses. Eising[50] who proposed its use observed that the bacterial count in the discharge from wounds so treated decreased, growth of granulation tissue was stimulated, and healing hastened. This effect he attributes to a bactericidal action

plus a stimulus to healing, both of which he believes are caused by secondary rays emanating from the petrolatum following irradiation. Lilienthal[51] has had similar results in the treatment of septic wounds and sinuses. Stevens,[52] and Sears and Black[53] have studied the bactericidal properties of irradiated petrolatum and have found them so feeble as to be negligible. The latter authors conclude that any beneficial action which irradiated petrolatum possesses must be attributed to a stimulating effect upon local tissue defense.

The maggot treatment of infected wounds as introduced by Baer,[54] particularly those in which devitalized and necrotic tissue is abundant, continues popular and effective. The method is, however, cumbersome, time-consuming, and often annoying to the patient. It has led to a study of the bactericidal and therapeutic effect of the secretions of maggots. Simmons[55] has obtained a potent bactericide from the excreta of maggots which kills various strains of virulent bacteria in broth or saline suspension in 5 to 10 minutes. The active principle is nonviable and is not destroyed by autoclaving or desiccation. It has not been used clinically. Robinson has suggested the use of urea[56] or allantoin,[57] each present in the excreta of maggots, for local application in the form of moist compresses to infected wounds. He feels that each substance will produce a general cleansing of the wound, reduce infection, stimulate formation of healthy granulation tissue, and hasten healing. Greenbaum[58] has had favorable results in the treatment of various types of wounds with allantoin used as a 0.4 per cent solution or as a 2 per cent ointment.

Zinc peroxide has been introduced by Meleney[59] for local application to wounds infected by the anaerobic group of organisms. He finds this drug particularly effective in producing a sustained highly oxygenated environment which inhibits and then destroys anaerobic organisms in the lesions. In a series of chronic undermining ulcers caused by a hemolytic streptococcus which prefers an anaerobic environment, he found zinc peroxide applied daily as a creamy suspension to be the only effective method of treatment available. He has also applied zinc peroxide locally as an adjunct in the treatment of wounds infected with *Cl. welchii* and *Cl. tetani*.

Azochloramide has been found by Kennedy[60] to be an effective chlorine-compound substitute for Dakin's solution. In Germany, Linka[61] has introduced "penetrin" as a cellular anesthetic of value in wound treatment, and Schweitzer[62] has used silver mannite for its stimulating, antisecretory, deodorant and epithelializing effect when applied locally to suppurating wounds.

INFECTIOUS GANGRENE OF SKIN AND SUBCUTANEOUS TISSUE

Since Cullen's[63] first description of a progressive postoperative gangrene of the abdominal wall following the drainage of an abdominal

abscess, interest has been stimulated in infectious gangrene of the skin and subcutaneous tissues. Stewart-Wallace,[64] in 1935, collected thirty-seven cases of progressive postoperative gangrene of the skin from the literature. Since then additional cases have been reported by Holman,[65] Hicken,[66] Coakley and Klein,[67] Willard,[68] and Liedberg.[69] Meleney[70] has classified the various forms of infectious gangrene of the skin and subcutaneous tissue into acute and chronic groups. Gas gangrene and hemolytic streptococcus gangrene represent the acute forms of the disease, while progressive postoperative synergistic gangrene, gangrenous impetigo or ecthyma, amebic gangrene, and fusospirochetal infections represent the chronic forms.

As described by these authors, progressive postoperative gangrene usually follows drainage of an abscess in the thorax or abdomen. The wound becomes painful, its margins dusky and elevated; and between it and the normal surrounding skin, an area of reddening appears. Gradually the process progresses; margins of the ulcer become necrotic, while an advancing zone of dusky cyanosis and another of reddening in the skin precede the advance of the gangrenous process. Huge areas of skin may become involved; Stewart-Wallace's case involved the entire back from occiput to iliac crests, the left flank, left side of the chest, and entire abdomen. In careful bacteriologic studies of his cases, Meleney[71] has uniformly found a microaerophilic nonhemolytic streptococcus to be present in the advancing margin of the lesion, while a hemolytic *Staphylococcus aureus* is present in the necrotic zone. By animal inoculation, he has shown that either organism injected alone causes no reaction, while a combination of the two usually produces a gangrenous lesion. His belief that the condition is due to a symbiotic phenomenon involving these two organisms has been widely accepted, although, because of a lack of uniformity of bacteriologic studies, other cases in the literature with one exception[68] did not show these organisms. In most of the recorded cases, at least two organisms have been found, and many authors have corroborated Meleney's observation that two organisms together produce more pronounced lesions than one alone. Regardless of any difference of opinion which may exist in regard to exact etiology, all agree on the futility of conservative measures in the treatment of the condition. A bold, extensive, and thorough excision of the margin of the ulceration, including the outer zone of redness, preferably with the cautery, has almost invariably resulted in a cessation of the process.

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Review of Recent Meetings

REVIEW OF THE SOUTHERN SURGICAL ASSOCIATION MEETING, DECEMBER 15, 16, AND 17, BILOXI, MISS.

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THE annual meeting of the Southern Surgical Association was held December 15, 16, and 17 at the Edgewater Gulf Hotel in Biloxi, Miss. The meetings were extremely well attended, and there were many important contributions. Of a total of forty listed papers, thirty-nine were presented.

Dr. George Heuer, of New York City, discussed **Surgical Aspects of Acute Cholecystitis.** His study included 150 cases from the Cincinnati General Hospital, 800 cases from the records of the old New York Hospital, and 614 cases from the new New York Hospital, a total of 1,565 cases. There is no direct parallelism between the stage of pathology of the inflamed gallbladder and the symptoms which these patients present. His studies showed that gangrene and perforation of the gallbladder occurred in approximately 20 per cent of the cases of acute cholecystitis. The mortality following perforation of the gallbladder averages approximately 46 per cent. He presented a series of 163 consecutive cases of acute cholecystitis in which operation was done early. In this group, 16 had perforation on admission. The mortality for the entire series of 153 cases was 3.2 per cent. Overemphasis has been placed on the danger of operation in the acute stages of cholecystitis, and the mortality is thus shown to be less from immediate than from delayed operation.

Dr. Frank Lahey, Boston: **Strictures of the Common and Hepatic Duct.** The most common cause of stricture is operative trauma, and probably the most common cause of injurious trauma at operation results from attempts to control bleeding from the cystic artery. Lahey described nine different types of reconstructive procedures which they have successfully employed for these strictures. The production of complete external biliary fistulas with later transplantation into the duodenum, stomach, or jejunum is not a satisfactory procedure. The Heineke-Mikulicz type of reconstruction, splitting the stricture longitudinally and suturing it transversely, is not applicable for long strictures. He uses a T-tube inserted into the reconstructed duct through a separate opening above the site of repair in these instances, the lower end of which passes down the duct through the site of repair. End-to-end anastomosis after the resection of a stricture should not have tension on the suture line, otherwise the lines of suture will give way. In some instances, he advises anastomosis of the obstructed duct to the duodenum or to the stomach. In rare instances, it is advisable to leave a T-tube in permanently.

Dr. Waltman Walters, Rochester, Minn., in discussing Dr. Lahey's paper, said that the end-results of a number of strictures (29) which he had reported before the Society in 1931 showed that approximately 50 per cent have remained permanently well.

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Dr. Frederick Coller, University of Michigan: **Treatment of Typhoid Carriers by Cholecystectomy.** He finds that 2 to 3 per cent of all typhoid cases become carriers; that is, they have persistent positive stools and positive bile cultures for a minimum of a year after the attack of typhoid. Coller performed cholecystectomies in such carriers which could not be cured otherwise. Ninety per cent of these were cured. The pathology of the removed gallbladder is usually that of chronic cholecystitis, but occasionally there is acute cholecystitis with intramural abscesses.

Dr. John deJ. Pemberton, Rochester, Minn.: **Regional Ileitis.** In a series of 39 cases examined at the Mayo Clinic and studied by Dr. Pemberton and Dr. P. W. Brown, the lesion was most frequently single but was occasionally multiple. It occurred usually in the terminal ileum but occasionally involved other segments of the intestinal tract. Changes in the small intestine which could be detected roentgenologically occurred early in the course of the disease. Clinically the cases present the following symptoms: frequently pain, sometimes with nausea, vomiting, and abdominal distention; occasionally diarrhea, loss of weight, anemia, and fever. The etiology is not known. The treatment of choice is a two-stage operation, the preliminary operation consisting of an ileocolostomy, subsequently resection of the diseased segment or segments. Of 9 cases of extensive regional enteritis, resection was performed in 2 and the patients have remained well for one year and for eight months, respectively. In the remainder of these cases, only the short-circuiting operation was performed, and the results have not been encouraging. Of the 27 cases in which the process was localized, in 19 the patients are well; 4 are still having trouble; 3 have died; and 1 has not been traced. In 8 of the 27 cases, a short-circuiting operation was the only operative procedure employed. In 3 cases in which only the short-circuiting operation was performed, a deficiency syndrome developed.

Dr. W. L. Estes, Jr., Bethlehem, Pa.: **Enteritis of the Obstructed Loop After Entero-anastomosis for Intestinal Obstruction.** Estes called attention to the fact that if a blind loop is left after an entero-anastomosis around obstructed lesions, the patient will develop signs of enteritis or enterocolitis. The treatment is resection of the blind loop. The condition is much more apt to occur when the blind segment is distal to the point of anastomosis and less likely to result when the blind segment is proximal to the point of anastomosis.

Dr. William Perrin Nicolson, Jr., Altanta, Ga., described a controllable cecostomy in which a mushroom catheter was placed into the cecum and a rubber guard like that of a Brauer tube placed over the tube externally, so that the cecal and abdominal walls were compressed between the two flanges. The tube is clamped when the patient is ambulatory, and no leakage occurs.

Dr. J. L. McGehee, Memphis, Tenn.: **Chronic Dilatation and Obstruction of the Duodenum.** Dr. McGehee reported a case of a female, aged eighteen years, who had severe vomiting spells for six weeks. Roentgenography showed obstruction of the terminal end of the duodenum. At operation there was a constriction at the terminal portion of the duodenum (congenital) which was due to pressure by the superior mesenteric artery and the middle colic artery on the duodenum. Duodenojejunostomy and colopexy to correct the drag were followed by cure.

Dr. Willis D. Gatch, Indianapolis, described a new method for closing a perforated ulcer on the anterior surface of the duodenum or pylorus. It consists of overlapping the proximal portion of a normal stomach for a distance of several centimeters over the ulcer onto the duodenum distal to the ulcer. In all, there were 26 cases, all men, with 5 deaths (19.6 per cent mortality). None of the 18 cases

operated upon within eleven hours of the perforation died. The mortality varied directly with the length of time elapsed after the perforation. Follow-up studies on these cases showed no disturbance in physiology and no obstruction to the outlet of the stomach.

Dr. Donald C. Balfour, Rochester, Minn.: **Factors of Significance in the Prognosis of Cancer.** Balfour summarized some of his experiences with cancer of the stomach which are significant in the prognosis. In a statistical study of over 2,100 cases of operations for gastric carcinoma, the following facts were obtained: The shorter the history, the less chance of cure; and the larger the tumor, the better the prognosis. A lesion at the pyloric end of the stomach was less amenable to cure than lesions of the body and fundus. There was less chance of permanent cure in cases with lymph node involvement, but after five years, patients with and those without lymph nodes involvement had practically the same chance of continued existence. Broder's grading showed a definite difference in the life expectancy, the Grade 4 types dying relatively much earlier than those of Grades 3, 2, and 1, respectively. The higher the gastric acidity, the better the prognosis. Forty-five per cent of cases are operable, but only 19 per cent of the cases are amenable to some type of operation (resection) which could possibly promise a cure. About 30 per cent of cases that have had extirpation of the growth and regional nodes will have five-year cures. Average life expectancy without palliative or radical operation is five months and with palliative operation (gastroenterostomy) is six months.

Dr. John C. Caulk, St. Louis. Caulk divided tumors of the renal pelvis and ureter into two pathologic types which have two entirely different clinical appearances. The papillary type comprises 80 per cent of the tumors and the squamous type, 20 per cent. The papillary type has a tendency to involve the respective ureter and does so in 50 per cent of the cases. They are multiple, slow-growing, and do not have distant metastasis. In this type it is important to remove the entire ureter, including the intramural portion in the bladder. If this is not done, 86 per cent will show recurrence. The squamous type of tumor metastasizes to distant regions but does not have a tendency to invade the ureter. Therefore, when the tumor is recognized as being squamous, it is not necessary to remove the ureter.

There were three papers on appendicitis. In general, it was emphasized that there are far too many deaths in the United States from appendicitis each year, that the mortality is still too high, that it is due to lack of education on the part of people and doctors.

Dr. Roy D. McClure, Detroit, reported a detailed study of 252 consecutive cases of acute perforated appendicitis with peritonitis. The mortality was increased with catharties and with complications present on admission. McClure emphasized the fact that 60 per cent of the patients had symptoms that were atypical of appendicitis but not signs which were atypical. Generally the objective findings are typical. He does not use the conservative treatment in cases that have developed complications. The mortality in his series was greater the closer the incision approached the midline. He favors the McBurney incision in acute appendicitis.

The majority of the discussers approved of the use of the McBurney incision in acute appendicitis and decried the use of right rectus incisions.

Dr. George H. Bunch and **Dr. Roger Doughty,** Columbia, S. C.: **Principles and Results in the Treatment of Acute Appendicitis.** The authors emphasize the technic of operation and the management of the case as the important factors in the mortality of appendicitis. They favor the expectant treatment in those cases which have developed complications, such as perforation with abscess, peritonitis,

etc. They emphasize that the greatest mortality occurs on the third, fourth, fifth, and sixth days of the disease and state that this is directional in its significance, i.e., to delay operative intervention during these periods. Bunch's mortality was, for unruptured group, 0.25 per cent; for ruptured group, 9.9 per cent; total mortality, 2.4 per cent. South Carolina has the lowest mortality of any state or any section of the United States. The reason, they believe, is due to Le Grand Guerry's teachings of the delayed operation in those cases of acute appendicitis which have developed complications from perforation.

Dr. E. P. Hogan, Birmingham, Ala., discussed the appendix problem by analyzing the mortality from various hospitals in Birmingham. They were variable, but the general trend was that in more recent years the mortality is becoming less. Hogan believed that the proper way of attacking the appendicitis problem was the education of the doctors and the public at large; he suggested that students should be taught in school what appendicitis is and the dangers of delay and neglect.

Dr. Deryl Hart, Durham, N. C., reported the results of his clinical and experimental investigations on the sterilization of the air in the operating room with radiant energy. By culturing the air in the room, he found a high degree of contamination. Reports from other men throughout the country who cultured the air in their operating rooms showed similarly a high degree of air contamination. The number of persons in the operating room increases the amount of contamination. Ultraviolet light at a distance of five feet practically sterilized contaminated agar plates within a period of sixty seconds for light contamination to five minutes for heavy contamination. The experimental evidence presented by Hart was very convincing. Installation of ultraviolet lights over their operating tables has reduced the incidence of unexplained infections following operation from 5.5 per cent to 0.6 per cent. The method necessitates wearing heavy covers for the heads of all the operating team and protection for the eyes.

Dr. Charles C. Green, Houston, Tex., reported an interesting case of local tetanus of the right arm occurring twelve days after injury. He cites this as an instance supportive of the view of Abel and his colleagues who believe that tetanus is not due to action of the toxin on the nerve or on the central nervous system, but due to direct action on the muscle itself.

Dr. W. M. Firor, Baltimore, in discussing Green's paper, cited some very important experimental work that has been done by Abel and himself. After injection of toxin directly into the central nervous system, hyperexcitability of the peripheral musculature but no increase in tone resulted. On the other hand, direct injection into the muscle caused stiffness and rigidity. They believe that the stiffness and rigidity is due to the local reaction on muscle, and that the hyperexcitability is due to the effect on the central nervous system.

Dr. Mont R. Reid, Cincinnati, discussed wound healing and emphasized careful operative technic and its relation to the healing of wounds. He stressed that living tissue has resistance to infection but that ischemia, strangulation, or hemorrhage in the wound enhances the growth of organisms. Antiseptics interfere with healing and injure the wound more than the contaminating organisms.

Dr. Edwin P. Lehman, University of Virginia, analyzed the postoperative record of the cases having had spinal anesthesia. Spinal anesthesia at the University of Virginia has been the method of choice for those operations below the diaphragm in which contraindications are not present. The results in 450 cases of spinal anesthesia and 450 cases of general anesthesia were compared. The cases selected for comparison were those in which postoperative complications would not be ex-

pected, such as herniorrhaphies, perineorrhaphy, hysterectomy. The incidence of nausea, distention, headaches, catheterization, backache were all less under spinal than under general anesthesia. Complications were slightly less, the postoperative course smoother under spinal anesthesia. The mortality for spinal anesthesia was 0.028 per cent. There was no end of proselytes convinced or becoming convinced that spinal anesthesia is a method which is safe and which has many advantages over the general.

In discussing this paper, **Dr. Hubert Royster**, Raleigh, N. C., brought the discussion to an anticlimax by asking for a vote by the surgeons expressing preference for spinal anesthesia or general anesthesia on themselves. The ones who preferred general anesthesia were very much in the majority.

In discussing this paper, **Dr. Lahey** made a plea for the education of anesthetists in the medical school, saying that most of the untoward results were due to unintelligent management or administration of spinal anesthesia.

Dr. Donald Guthrie, Sayre, Pa., discussed avertin anesthesia, reporting a death which was due to respiratory failure and reporting statistics and impressions that he had gained from communications with other surgeons. The consensus of opinion was that avertin anesthesia is a valuable adjunct to anesthesia, though many men will not use it, and others are suspicious of its untoward results.

Dr. Rudolph Matas, New Orleans, after receiving the standing respect of the members, reported a most interesting case of cavernous angioma of the arm with regional recurrence and distant metastases. The patient at birth had an angioma on the finger of the hand. In fifteen years because of the progress of the lesion upward, he had an amputation in the middle of the forearm. When the patient was twenty-one years of age or six years after the amputation of the forearm, there was noted an angioma in the stump; at this time the systemic and local symptoms of arteriovenous fistula were apparent. At the age of twenty-one years, the arm was disarticulated at the shoulder and ten years later the patient had evidence of another recurrence in the chest wall in the region of the amputated stump and also at some distance below on the chest wall. There was a sponge-like angiomatous lesion that permitted direct passage of blood from arteries to veins. The patient had an enlarged heart and signs of cardiac weakness on exertion. All local signs of an arteriovenous communication were present.

Dr. Arthur M. Shipley and **Dr. Nathan Winslow**, Baltimore: **Extracranial Aneurysm of the Internal Carotid: Report of Two Additional Cases and Review of the Literature.** Many of these cases have been discovered accidentally by the surgeon opening the protrusion into the pharynx, thinking it was a peritonsillar abscess. Occasionally such lesions have ruptured spontaneously into the pharynx. It is important to be cognizant of the lesion. Whereas the lesion is extremely rare, Shipley and Winslow emphasize the dangers of the incorrect diagnosis. The operation of choice is ligation of the internal carotid artery; they advise preliminary approach under local anesthesia and temporary ligation to test the collateral circulation by noting any evidence of dizziness or other symptoms that might indicate an impending cerebral accident. If the patient weathers the preliminary operation, the prognosis is good for permanent cure.

Dr. Foy Roberson, Durham, N. C., in discussing cancer of the female breast, called attention to the fact that the deaths from cancer are 9.9 per hundred thousand population in the United States yearly. In North Carolina, one in 200 deaths is due to carcinoma of the breast. Roberson believes the most important changes which would produce an improvement in the management of cancer would be the delegation of all carcinomas of a certain portion to the care of one man in charity hospitals of small communities where there are relatively a small number of

cases. He believes in this way the community would have an expert in each particular phase of cancer therapy, and that there would be more interest and that the patient would benefit.

Dr. Frank P. Strickler, Louisville, Ky.: **A Satisfactory Method of Repairing Crucial Ligaments.** Strickler believes that not all cases need operation, but only those which do not have a satisfactory result from the conservative treatment, that is, prolonged immobilization. Rupture of the anterior crucial ligament permits anterior dislocation of the tibia on the condyles of the femur in extension, and rupture of the posterior crucial ligament permits posterior dislocation of the articular surface of the tibia from the condyles of the femur with the knee in flexion. Strickler's technic consists of a long lateral incision on the thigh through which he obtains a wide piece of fascia lata which when rolled is as thick as a pencil. This is threaded through a drill hole which goes into the femur above the condyle down into the intercondylar notch, and then through a drill hole which passes from the interarticular superior surface of the tibia anterior to the spine through the tuberosity, emerging laterally. The fascia lata is not secured here, but is carried back to its point of origin and sutured to its other end.

Dr. Charles S. Venable, San Antonio, Tex.: **Experimental Study of the Changes in Bone in the Presence of Metals Based Upon Electrolysis.** Venable reported some very interesting and significant experimental work done by himself, Walter G. Stuck, and Asa Beach, the object of which was to determine the causes of the changes in bones in the presence of metals. He showed definite osteoporosis occurring in those instances in which there were two metals, even if they were in one foreign body, such as one screw, which permitted electrolysis from one metal to another. In instances in which osteoporosis was occurring, they obtained by chemical analysis copper, zinc, chromium, or iron, etc., in the region around the foreign material and also in distant organs such as the liver. This was interpreted as being significant of the fact that electrolysis made the migration of ions from one metal to another. They concluded that such electrolysis produced absorption around the screws or osteoporosis, because in material which had no ions in the surrounding tissue or in distant organs, e.g., in vitallium, which does not contain iron, there was no tissue reaction and there was no evidence of osteoporosis. They believe that this explains the osteoporosis that occurs from foreign bodies and they submit a formula for a metal which would result in a minimum reaction.

Dr. Willis C. Campbell, Memphis, Tenn., stated that he had 495 cases of fractures of the neck of the femur, of which 214 (43 per cent) were complete intracapsular fractures, 229 were intratrochanteric, and 52 were impacted fractures. Internal fixation is not new, but the advent of lateral as well as anteroposterior x-rays has made it feasible to be sure reduction has been accomplished, and he believes that this with internal fixation is responsible not only for a more comfortable convalescence, but also for higher percentages of union. In 19 cases in which this method was used by him on intracapsular fractures of the neck of the femur and which have been followed for a sufficient length of time, all have shown bony union.

Dr. Urban Maes, New Orleans, previously reported a mortality rate of 7.6 per cent in 341 thyroidectomies at Charity Hospital. In the last two years, there have been 321 thyroidectomies with a mortality of 3.7 per cent. There is a high mortality in the negro race, 12 per cent. Fifty-four men operated upon these 662 cases. Some of their cases were studied for liver function with the hippuric acid test, and it was found to be an index of the risk of the operation. In severe risks, the liver function is low, and it is possible to follow quite closely the clinical improvement in the patient before operation with this test.

Dr. Earle Drennen, Birmingham, Ala., analyzed 300 consecutive cases of thyroidectomy which he himself had done. He claimed nothing original, but showed an extremely low mortality of 1 death in the 300 cases, one-third of one per cent. These favorable results Dr. Drennen attributed to detailed study of the cases and careful preparation of the patients before operation.

Dr. Willard H. Parsons, Vicksburg, Miss.: **Treatment of Heart Disease by Total Ablation of the Normal Thyroid.** Drs. Parsons and Purks sent out a total of 677 questionnaires, and 342 replies were obtained relative to the treatment of heart disease by the total ablation of the normal thyroid. Of those who replied, 59 had had definite experience with the operation. The results in these cases and 4 of Dr. Parson's own were analyzed. In 229 cases of congestive heart failure represented, there was an operative mortality of 10.48 per cent. The results were excellent in 34.6 per cent, and satisfactory improvement was obtained in approximately 60 per cent. In angina pectoris, the results were even better. In 133 cases, the mortality was 3.75 per cent; the excellent results were obtained in 55.46 per cent; and moderate improvement occurred in 28.12 per cent. He believes that the status at present is that good or satisfactory improvement occurs from thyroidectomy in angina pectoris in 80 to 90 per cent of the cases.

Dr. Lon Grove, Atlanta, Ga.: **Fibroangioma of the Spleen.** Dr. Grove reported a case of a four-month-old infant who was normal at birth but who subsequently developed a lump in the left upper quadrant of the abdomen. This was removed at operation and a tumor 5 by 5 cm. in diameter was found in the spleen. Microscopically it proved to be a fibroangioma. These tumors are extremely rare.

Dr. Louis Frank, Louisville, Ky., reported a case of hemolytic streptococcal infection of intraabdominal lymph nodes in which suppuration occured. They have found reported only six similar cases. The patient's initial portal of entry was the foot. The patient was extremely ill. Incision and drainage of an abscess was followed by ultimate recovery. Repeated blood transfusion and x-ray therapy did not seem to arrest the disease in this instance, but an intravenous injection of metaphen was followed by prompt improvement. The duration of the illness was eleven weeks.

Dr. I. M. Gage, New Orleans, in discussing Dr. Frank's paper stated that on the Tulane Surgical Service they had had between 25 and 30 cases of streptococcic lymphadenitis. In only 2 cases was *Streptococcus hemolyticus* obtained. Dr. Gage advises preliminary aspiration determining the type of organisms and if it is streptococcus, nonintervention treatment until actual suppuration has occurred, in which instance incision and drainage is indicated. He advises strongly against incising and draining before signs of suppuration.

Dr. Albert O. Singleton, Galveston, Tex., reported twenty-eight cases of lymphangioma. They were divided into simple, cavernous, and cystic types. There were 11 cases of the simple type and 17 cavernous or cystic. Dr. Singleton reviewed the embryologic development of the lymphatic system and showed how such congenital cysts could develop. Infection is a frequent cause of death after operation. One particularly interesting case was that of an infant with an extensive congenital lymphangioma of the arm extending up onto the chest and the base of the neck. Operation was done to remove part of the lesion from the base of the neck. One year later, the patient had signs of an infection and died from what was thought to be a pneumonia. Postmortem examination revealed that the tumor had extended into the mediastinum and into the right side of the chest and had become infected.

Dr. K. H. Aynesworth, Waco, Tex., gave a general discussion of medical and surgical lesions above the diaphragm which present symptoms simulating acute surgical lesions in the abdomen. It is important that lesions above the diaphragm produce no abdominal rigidity. If sudden palpation is done, it may cause a reflex rigidity which may give an erroneous impression, but if the type of examination Aynesworth advises is carried out there is no rigidity. He advises gentle, light palpation with the finger, very light, to detect any rigidity followed by gentle, firm, and increasing pressure with the palm of the hand in the region of the pain. In those instances in which the lesion is above the diaphragm, although there may be a slight sense of resistance at first, it disappears when the pressure is continued.

Dr. C. C. Coleman, Richmond, Va., gave a very important paper on the surgical treatment of facial spasm. In discussing this paper, **Dr. Joe King,** of New York City, said that it was the most informative paper he had heard on this particular subject. Coleman had in the last year five cases of facial spasm of unknown etiology. Three were unilateral and two were bilateral. In unilateral cases, the pathology is in the peripheral nerve; in the bilateral cases, it is in the cerebrum. The character of the spasms is different in the two types. Alcohol injection of the facial nerve is not simple; it paralyzes the entire nerve. He prefers division of the nerve anterior to the ear, preserving the mandibular branch and resuturing the upper fibers. This keeps the mouth balanced. He believes that facial hypoglossal anastomosis after division of the facial nerve will offer perhaps even better possibilities for a permanent cure in this unfortunate condition.

Dr. Ernest Sachs, St. Louis, in order to attack with radiation therapy malignant tumors of the brain and cranial cavity, irradiated cases on the table when the bone flap had been turned and the adjacent skin and skull were protected by lead. In five cases, they gave over 600 roentgen units, and it is now possible by elimination of certain filters to do this in forty minutes. As yet, they have not followed the cases for a sufficient length of time to give the result. They had previously tried the implantation of radium, and the results in these malignant cases were not satisfactory; therefore he was glad to discard it for something which promised better results.

Dr. E. Dunbar Newell, Chattanooga, Tenn., discussed the treatment of brain trauma by the general surgeon. There are approximately 112,000 cerebral injuries in the United States annually, and the mortality possibly averages around 25 per cent. Most of the cases have to be treated, not by neurosurgeons, but by general surgeons. In a previously reported series, they had a mortality rate of 31 per cent. In their present group, it was reduced to 20 per cent. In the last 100 cases, there have been five deaths. Six were operated upon for depressed fractures, two for middle meningeal syndromes. Newell emphasized that the patient should not be changed and molested by moving, but should be put at rest; he cautioned strongly against intervention or meddlesome surgery except where it is absolutely indicated.

Dr. Daniel C. Elkin, Atlanta, Ga., showed a motion picture in colors of suturing a stab wound of the heart. The presentation was striking and illustrated nicely the heart tamponade and its relief by the gush of blood from the pericardium following incising the pericardium. They have had 18 cases, 13 of which have been operated upon by Dr. Elkin. Of the 18, 7 died, 11 recovered.

Dr. Lucius E. Burch and **Dr. John C. Burch,** Nashville, Tenn.: **The Technic of Perineorrhaphy.** They presented a paper on a method for the repair of a rectocele. As a preliminary to operation, they infiltrated under the mucosa with adrenalin 1 to 120,000 in ¼ per cent novocaine as a hemostatic measure. The

mucosa is removed with scissors. The vaginal fascia is then incised. After reducing the rectocele by a plication, they expose the levators and suture them under the rectocele.

Dr. Hilliard R. Miller, New Orleans: **Echinococcal Disease, With a Report of Primary Echinococcal Cyst of the Uterus.** Dr. Miller reported an interesting case of an echinococcal cyst of the uterus, the first occurring in North America. The patient, a colored woman, evidently obtained infestation by eating clay during pregnancy, which she thought was beneficial. The tumor, the size of a grapefruit, was attached to the uterine wall and was removed by doing a partial fundusectomy. On sectioning the tumor subsequently it proved to be a typical echinococcal cyst. The patient always has lived in Louisiana. There has been no recurrence since the operation.

Dr. John T. Moore, Houston, Tex., called attention to the Shropshire operation. This operation for hysterectomy is done by cutting through the lateral wall of the uterus itself instead of cutting through the broad ligaments. Preliminary to cutting the slab, special clamps are applied to stop bleeding. It is a rapid method of doing a hysterectomy. In closure, the lateral stumps, which consist of part of the wall of the uterus, are sutured together by mattress sutures. This forms a strong protective closure and tightens the uterosacral and uterovesicle ligaments. The same procedure can be used with slight modifications on vaginal hysterectomies.

Dr. Curtis H. Tyrone, New Orleans, reported 206 cases of vaginal hysterectomies which he had done personally between August, 1931, and November, 1936. These cases were done in instances in which such an operation was one of choice for the particular pathology, that is, in cases in which the cervix was diseased and in which there was a prolapse. The operation is not indicated in all cases, but one should be able to do a hysterectomy either by the vaginal or by the abdominal route. In his series of 206 cases, he had the extremely laudable mortality rate of less than 0.5 per cent, 1 death. There was complete relief of symptoms in all cases except one. Preoperatively, 204 of the cases had leucorrhea and 205 had backache.

Book Reviews

A Textbook of Surgery. By American Authors, edited by Frederick Christopher. Cloth. Pp. 1608, with 1349 illustrations. Philadelphia, 1936, W. B. Saunders Company. $10.00.

This new textbook of surgery is distinctive in that it is not the work of a single individual or of a small group of men, but the product of the combined labors of some 180 contributors, each eminently qualified to discuss the topic assigned to him. The research training, bibliographic knowledge, and wide experience of the individual authors leave their imprint upon the pages of the book.

The general outline is much like that of other textbooks of surgery, although in some respects there are departures from the traditional pattern. The early chapters deal with inflammation and bacteriology, but the discussion of aseptic surgical technic is found near the end of the book linked with some excellent chapters on minor surgical procedures, anesthesia preoperative and postoperative care. Diseases of the thyroid gland and of the islands of Langerhans are discussed under the heading "The Endocrine System" rather than in the sections devoted to the neck and the pancreas.

The text embraces the broad field of the general surgeon and includes special chapters devoted to orthopedic surgery, plastic surgery, and gynecology. Roentgenology, diagnostic and therapeutic, is given space commensurate with its importance in surgical practice, an entire chapter being devoted to this subject.

No very rigid outline has been followed in the writing of the different sections, but there is the usual division of material under descriptive headings such as: definition, etiology, symptoms, diagnosis, prognosis, and treatment. There are only occasional brief references to the history of surgery. Some authors more than others have stressed the fundamental sciences upon which surgery is based. The lack of uniformity in this respect is not due necessarily to the varying points of view of the different contributors, but is due largely to the nature of the subject requiring elucidations. For example, in describing the treatment of fractures, frequent references to anatomic facts are found to be helpful; and in the section on diseases of the thyroid gland, fundamental data concerning not only gross and microscopic anatomy but embryology, physiology, and chemistry are included. The importance of bacteriologic data is not always stressed sufficiently, but there are sections in which bacteriology has been given adequate consideration, as in the case of acute empyema. Perhaps it is sufficient that an early chapter deals with the relationship of bacteriology to surgery.

The discussion of the many aspects of clinical surgery in this book includes references to some of the newer principles and methods of treatment. In the section on fractures are to be found the modern methods of skeletal traction, "well-leg traction," and a description of operative procedure in fractures of the femoral neck. The discussion of diseases of the ductless glands has been brought up to date. The chapter on "Cancer of the Breast" includes an able discussion of radiotherapy. The use of suction siphonage through the duodenal tube in intestinal obstruction is described and the chapter on "Orthopedics" features a discussion of painful affections of the lower back. Most of the chapters, however, may be described essentially as adequate, comprehensive, and direct.

No outstanding weaknesses or obvious misstatements were encountered. A few subjects, notably resuscitation and chronic empyema, are discussed so briefly that these sections of the textbook will be of little value to the student or practitioner who is seeking information on these subjects.

One may well question the logic of the arrangement of some of the material in this book. The chapters on roentgenology and gynecology inserted after plastic surgery and preceding the sequence "The Head," "The Neck," "The Breast," etc., appear to be out of place. However, as the index is adequate, no difficulty should be encountered in discovering the material to be found in these or in any other chapters.

Everything considered, Christopher's *Textbook of Surgery* deserves high recommendation. As a modern, practical textbook of surgery, it has no superior in the English language.

Post Graduate Surgery, Vol. I. By Rodney Maingot. Two volumes. Pp. 1742, with 1980 illustrations. New York, 1936, D. Appleton-Century Company, Inc. $15.00 each.

This volume, the first of a group of three under the title *Post Graduate Surgery* by British authors, appears with an American foreword by Dr. Eugene H. Pool and an introduction by the late Lord Moynihan. The editor is Mr. Rodney Maingot, senior surgeon in the Royal Waterloo Hospital. This volume of 1742 pages contains in five parts chapters on the following subjects: the abdomen, the rectum and anus, x-ray diagnosis, and radium treatment. Twenty authors have pooled their knowledge from special fields to make this an authoritative text. A complete and useful index is appended also.

In three major sections written by the editor, viz., surgery of the stomach and duodenum, the biliary passages, and the spleen, a standard of excellence has been set which is rarely surpassed in the writing of medical texts. The well-balanced and temperate consideration of the subject matter in all these sections is deserving of high commendation. Sections equally meritorious are written by Hamilton Bailey on the vermiform appendix, in which are well described the operative treatment as well as the conservative management of late cases; by A. John Cokkinis on intestinal obstruction and peritonitis, and by W. Ernest Miles on the rectum and anus. The latter section alone occupies 222 pages. The chapters on anesthesia, x-ray diagnosis, and radium treatment, though considerably briefer, are well done and constitute reliable sources for useful information in each field.

The task of an editor in directing the publication of a work of this kind is no light matter, and the difficulty of securing the same standard of performance by all authors becomes readily apparent. The services of an artist whose function it would be to try to have all illustrations conform to a certain standard could be well employed in such an enterprise. The appearance of the text would thereby be appreciably augmented. Duplication, some of which is useful, has also crept in. This is particularly evident in the chapter on peritonitis, where some of the details of the primary conditions previously described are again repeated. The treatment of the subject of ileus by the late H. Tyrell-Gray is so unusual and unique that despite 210 pages of excellent discussion of the subjects of intestinal obstruction and peritonitis by Cokkinis, it does not appear out of place. Some may still question whether Gray satisfactorily substantiated the distinction which he makes between active and paralytic ileus. The chapter on the pancreas is all too brief, and no reference is made to the operation of Allen Whipple for carcinoma of the ampulla; hypoglycemia due to hyperinsulinism receives bare mention. Certain

provincial expressions not understandable to the general reader are found here and there. The reader may, with some justifiable irritation, inquire what is the Graham ladder diet or the Lawrence line ration diet and what is kerol.

The reviewer would have liked to have seen Devines' interesting operation for carcinoma of the colon described at greater length; yet no reference to it appeared in the bibliography. Mr. Wakeley in the section on the colon also minimizes the importance of acute obstruction of the colon and fails to point out the danger of perforation, particularly of the cecum. One is led to wonder why exteriorization of the colon is spoken of as the Mikulicz-Paul operation, particularly since Mikulicz's description of the operation was made in 1903, and Paul, a native Englishman, gave a lucid description of his operation in 1900. It should also not be forgotten that exteriorization of the colon was well described by the Danish surgeon, Bloch, in 1892. Cokkinis leaves the reader with the wholly erroneous impression that roentgen examination with the scout film of the abdomen is unnecessary in the diagnosis of bowel obstruction. His statement that sudden decompression of the bowel obstruction is dangerous would appear to need more proof than is now available upon the matter. In the light of Eiselsberg's experience with gastric exclusion performed simultaneously with gastroenterostomy for duodenal ulcer, this procedure would not seem to have much justification.

This authoritative and practical volume on surgical subjects by British authors is not a provincial surgical treatise; it has absorbed the best and newest from all surgical literature. It should find an enthusiastic reception by an audience of American surgeons. The second volume has already appeared, and the third will be awaited with interest.

Textbook of General Surgery. By Warren H. Cole and Robert Elman. New York, 1936, D. Appleton-Century Company.

The ever widening realms of surgical endeavor, the rapid advances made during short periods of time, the present-day tendency of intensive specialization, and the diversified and controversial opinions held on many subjects make the writing of a satisfactory textbook of general surgery an almost Herculean task. Thus, the appearance of a new textbook covering the entire field of surgery compiled and edited by two authors is worthy of some consideration, if from no other standpoint than to applaud the indomitable courage and the diligent assiduity required in the preparation and completion of such an operose undertaking. The authors deserve more than this commendation, however, as they apparently fully appreciated these obvious difficulties and have confined themselves, as they state in their exordial remarks, to the simple compilation of the more important principles of surgery for the undergraduate student. In the prefatory words of Evarts Graham, to whom the book is respectfully dedicated, it "is the outgrowth of a course given to the junior students of the Washington University School of Medicine." With this idea in mind and without entering on any lengthy encomium, it should be remarked that the authors merit unstinted approbation.

The scheme and manner of presentation differ little from that of most surgical texts. The early chapters consist of compendious considerations of the underlying principles of inflammation and repair, surgical bacteriology, asepsis and antisepsis, surgical methods, wounds, miscellaneous infections, and shock and hemorrhage. These are followed by complete but succinct expositions of the more important surgical diseases affecting the various systems of the body. The section devoted to the investigation of the emergency prostrate patient is noteworthy for its lucid and instructive manner of presentation. As would be expected, the

subjects of liver, gallbladder and biliary tract disease, and thoracic surgical diseases are exemplary dissertations for undergraduate students. It is regrettable that not as much can be said for the last three chapters, which respectively consider the endocrine glands, gynecology, and the genitourinary diseases. However, the usual characteristic fluctuation in emphasis of various phases of surgery, according to the particular interest of the authors, is remarkably minimized.

Following each chapter there is a concise, pertinent, and up-to-date bibliography for those desiring greater detail. The illustrations are profuse, demonstrative, and in general commensurate with the text, but they are unfortunately marred by the mediocrity of the drawings. Although many of the illustrations are borrowed from other sources, particular attention is called to the inaccuracy of crediting the original author.

Its study is particularly recommended to the junior and senior medical students, who as a group require emphasis upon pathogenesis and necessitate the presentation of the subject matter from the physiologic point of view in order to better understand the rationale of therapy. In accordance with this idea, the authors have faithfully and laudably achieved their difficult task.

Urology. By E. L. Keyes and R. S. Ferguson. Sixth edition. Cloth. Pp. 697, with 343 illustrations. New York and London, 1936, D. Appleton-Century Company, Inc. $10.00.

The recent appearance of a number of textbooks of urology differing considerably one from the other raises the question of what such a book should aim to accomplish. The resulting speculations have led the reviewer to formulate the following objectives as reasonable.

1. To supply the fundamentals in easily assimilable form to the medical student; 2. to answer the practical questions of the practitioner who is not a specialist; 3. to supply the student of urology as a specialty with an understanding both of the fundamentals and of the details; and to serve him and the urologist already trained as a source of reference to the literature.

Keyes' and Ferguson's *Urology* fulfills the first two objectives but does not fulfill the third because it contains no bibliography, an omission doubtless made deliberately to avoid excessive bulk. Moreover, it is no longer possible to treat urology extensively from the third point of view in less than two, or possibly even three, volumes.

Especially deserving of praise are the sections on instrumentation with emphasis on its purposes and dangers. There is a tendency among those just attaining some proficiency in instrumentation to regard "passing the cystoscope" as a neat trick and to forget that diagnostic cystoscopy is only a means of making a diagnosis and not an act in itself. Such persons need the cautious reminders expressed in these reactions. The tests of renal function are well discussed from the viewpoint of practical urology. The discussion of congenital anomalies is good but fails to give the student a working conception of pseudohermaphroditism.

The attitude of the authors toward such controversial topics as nephralgia and renal sympathectomy, nephroptosis and nephropexy, and ureteral stricture and dilatation is pleasingly thoughtful and conservative. Their view of postoperative urinary retention with its urgent plea for early and frequent catheterization to prevent damage to the bladder by distention ought to be brought to the attention of every surgeon.

The section on prostatism is noteworthy for its frank discussion of the mortality of prostatectomy under the less than ideal conditions that prevail in most public

hospitals. Their grave misgivings about transurethral reaction as performed by those without adequate training are more than justified; they are perhaps a trifle too skeptical of its value and safety in more experienced hands.

There are admirably concise discussions of stone and tuberculosis, and the consideration of neoplasms of the urogenital tract is noteworthy; however, it is doubtful whether many urologists have learned to expect quite so much from irradiation, or to be quite so skeptical of surgery as are the authors.

Their observation that irradiation controls 29 per cent of all testicular tumors for five years, while radical operation controls but 17 per cent of selected cases is most interesting. The technic of irradiation with the x-ray and with radon is very fully described.

Traumatic lesions are well considered, and the discussions of pre- and postoperative care and of derangements of the sexual function are especially well presented.

On the other hand, certain criticisms should be offered. The book contains many widely used medical and urologic terms which cannot win the approval of the purist, such as the use of "physiology" for function, "perinephritic" for "perinephric," or "perirenal" and "retropyelitic" for "retropelvic."

More important than these trivialities is the absence of good general discussion of neurogenic visical dysfunction and of pseudohermaphroditism, a lack common to most textbooks of urology. Nevertheless, the treatment of the paralyzed bladder traumatic myelitis by the avoidance of catheterization is admirably presented.

The section on operations is valuable but occasionally somewhat sketchy, particularly in the case of hypospadias where the only method of straightening the penis which is described in that of Hagner, and the only method of constructing a new urethra that of Ombredanne. It would be difficult for any one to comprehend fully the details of the latter operation from the description in the text unaccompanied by diagrams. Surely the eminently satisfactory operation of Thiersch deserves mention; the subject should not be dismissed by saying that "the future of hypospadias lies in the hands of the plastic surgeon." Such problems belong definitely to the urologist.

It is difficult to refrain from taking issue with certain statements. For example, it is doubtful whether the bladder must always contain 600 c.c. to be palpable, that the calices, pelves, and ureters normally lie empty, that excretory urography would often be valueless except for the making of cystograms, or that the nocturia which precedes retention in prostatism is due to renal polyuria secondary to impaired renal function since it often occurs before the renal function is impaired.

The statement that approximately 5 per cent of urologic patients die of pulmonary embolism is apparently a misprint; also, one may question whether it is justifiable to tell students dogmatically that sudden emptying of the distended bladder is dangerous without submitting adequate proof that this is so.

Finally it would be interesting to know what the authors meant by "vicious sexual hygiene," a rather vague term long in honorable use in urology.

Notwithstanding these minor criticisms, this is an unusually satisfactory textbook of urology which should prove very useful to general practitioners and students.

Diseases of the Coronary Arteries and Cardiac Pain. Edited by Robert L. Levy. Pp. 426, with 74 illustrations. New York City, 1936, The Macmillan Company. Price $6.

The subduing of the great epidemic diseases and the concomitant "aging" of our population have resulted in the elevation of diseases of the heart to the position of prime importance in medicine. The great increase in death rate from heart disease is practically entirely due to the increase in heart disease associated with

hypertension and with disease of the coronary arteries. Within a period of only twenty years, our knowledge of the anatomy and the physiology of the coronary arteries, as well as our knowledge of the symptoms and signs of heart disease associated with disease of these arteries, has increased enormously. Within this same period of time the mechanism of cardiac pain has been elucidated. Surgical measures for the relief of cardiac pain and for the treatment of the heart failure associated with disease of the coronary arteries have been devised quite recently. Knowledge in this field of such great importance to the physician is widely scattered in journals of physiology, pathology, medicine, and surgery.

Physicians and investigators have long felt the need for a comprehensive summary of our knowledge in this field. This work appears to the reviewer to meet admirably the needs of both the physician practicing at the bedside and the investigator working in the laboratory. Fourteen American physicians and scientists, who have themselves made valuable contributions to our knowledge of the coronary arteries and their diseases, have contributed authoritative chapters to this work. Every chapter has a comprehensive bibliography to guide the student who desires to delve deeper. The practicing physician will not only find chapters on the physiologic and pharmacologic background for a rational treatment of angina pectoris, coronary thrombosis, and congestive failure due to coronary arteriosclerosis, but he will also find chapters devoted to a description of the medical and surgical treatment of these conditions. The surgeon will find a brief but adequate treatment of the subject of "paravertebral alcohol injections, ganglionectomy, and posterior rhizotomy for the relief of cardiac pain" in James C. White's chapter on this subject. Blumgart's chapter on "total thyroidectomy for the relief of cardiac pain and congestive heart failure" will serve the surgeon as an introduction to this subject, upon which the last word has not yet been said. Claude S. Beck contributes a chapter on "the development of a new blood supply to the heart by operation" which every surgeon will want to read. It should serve as a stimulus to some of the younger surgeons to join Beck in pioneering in this field. The reviewer desires to recommend this book very highly to all physicians.

American Chamber of Horrors. By Ruth DeForest Lamb, New York, 1936, Farrar & Rinehart, Inc.

The title of this book suggests either a detective story or a glance behind the scene of an inquisition room of a prison or court. Actually it is neither. It is the inside story of the government's fight to protect consumers against danger to health, life, and pocketbook. The title is the name which the press applied to the exhibit of injurious and fraudulent products that the food and drug administration set up to illustrate defects of the existing pure food and drug law at the time that a revision of this law, the so-called Copeland bill, was being considered by Congress.

Realizing that a pure food and drug law exists, the public places infinitely more confidence in the protection which they think this law provides than the facts of the situation justify. This book shows, largely by illustrative cases, the loopholes in existing legislation which permit well-known quacks to continue to exploit the public even though the character of their businesses is thoroughly understood by various agencies of the federal government. The present law merely closes the channels of interstate and foreign commerce to products which are adulterated and misbranded.

The existing pure food law was enacted in 1906. In 1912, it was amended to forbid false and fraudulent therapeutic claims on labels of patent medicine con-

tainers. This would seem to provide more protection than it actually does, for the law is worded so as to require the government to prove that claims are fraudulent before any action can be taken against the producer. He cannot be convicted under this law unless it can be proved that he actually knows that the claims are false. If he can convince the jury trying the case that he, himself, believes in the value of his product, he will be acquitted. Furthermore, this law does not hold the manufacturer of a proprietary or patent medicine legally responsible for false claims which are made for his product through the various channels of public advertising. Proprietary medicines formerly labeled as specific cures for cancer or diabetes continue to be sold, immune from prosecution, merely by a change of label and a limitation to collateral advertising of their claims to cure cancer, diabetes, etc. Such advertising, particularly since the advent of the radio, reaches infinitely more prospective buyers than could corresponding claims on the label of the package.

The present food and drug act provides no protection against the potentially dangerous drugs which are contained in certain "patent medicines." Detailed reports are given of serious toxic results, and of several deaths from the use according to directions of various nationally advertised and widely sold medicinal and cosmetic preparations. It is illuminating to see detailed reports of the constituents, the claims, ownership and promotion methods of many of America's most famous remedies, such as Crazy Crystals, Cascarets, Jad salts, Tanlac, Marmola, Fleischmann's yeast, Cherry Pectoral, Vick's VapoRub, Lydia Pinkham's Vegetable Compound (the virtues of which were recently extolled in a full-page advertisement in the new magazine *Life*), etc.

The fearlessness and frankness of the author in discussing these products excite the admiration of the reader. She would not dare to make the statements she does if they were not true. Startling disclosures are presented concerning the adulteration, mislabeling, and false claims made for many foods which effective and persistent advertising has led the American public to accept as standards of excellence. The possibilities of poisoning with lead arsenate and pyrethrum from fruit and vegetables which have been sprayed with insecticides is considered at some length.

The final chapter of the book presents an interesting story of the recent attempts to induce Congress to pass a new and more effective food and drug law. The bill which was formulated largely by the food and drug administration was introduced by Senator Copeland in June, 1933. This proposed law would not do away with the so-called patent medicine business, but it would give the consumer a better idea as to what he is buying, and it would prevent false advertising claims as to the value of these various preparations.

The introduction of this bill gave rise to immediate and determined activity on the part of the patent and proprietary medicine groups and associations. They usually referred to the bill as the Tugwell bill because Mr. Tugwell had been interested in having some law enacted which would give the American public better protection in this regard than it has at present. On the one side, the food and drug administration with the backing of certain consumer groups has been attempting to convince congressional committees that a better law should be passed. On the other side, the manufacturers and jobbers of proprietary medicines, employing powerful lobbies, bringing pressure upon advertising agencies and through them upon newspapers, magazines, retail druggists, beauty parlors, and other retail corporations, have been attempting to block the passage of any law which will curtail their profits. It is a most interesting and enlightening, although disheartening, story.

The author concludes that "there is going to be a law." If the American public were familiar with the facts presented in this book, this prediction doubtless would come true and that very promptly. Unfortunately, facts such as these will not reach any considerable proportion of the population. Public opinion will con-

tinue to be based largely upon misinformation disseminated by press, radio, and other advertising agencies which profit handsomely from the patent medicine business as it now exists.

The appendix contains much interesting and valuable information relative to the fortune of the Copeland food and drug bill in Congress; the President's message to Congress relative to this act; the roll call of the Senate on the proposed amendment to this bill; the provisions which are essential in an act to protect the consumer; the costs and ingredients of well-known cosmetics; the quality grades of many widely advertized canned foods; the list of members of the Proprietary Medicine Association and of the Institute of Medicine Manufacturers (the reviewer was interested to find twelve members of the latter association in his own city, ten of which were firms that he did not even know existed); and the resolution of the American Federation of Labor relative to this law. The bibliography is extensive and specific for the various chapters of the book.

The author of this book has made a significant contribution in presenting as an absorbing story a subject in which everyone is, or at least should be, vitally interested. Physicians will find it illuminating and interesting and will do well to recommend it widely.

Books Received

The receipt of books is acknowledged in this section and this statement must be regarded as sufficient acknowledgment of the courtesy of the sender. Selections will be made for more extensive review dictated by the interests of our readers and as space permits.

WILLIAMS OBSTETRICS: A TEXTBOOK FOR THE USE OF STUDENTS AND PRACTITIONERS. By Henricus J. Stander, Cornell University Medical College. Cloth. Price $10. Seventh edition: A revision and enlargement of the text originally written by J. Whitridge Williams. Pp. 1269, with 729 illustrations. New York, 1936, D. Appleton-Century Company, Inc.

LAW OF DRUGS AND DRUGGISTS. By William R. Arthur, University of Colorado. Cloth. Price $3. Pp. 487. St. Paul, 1936, West Publishing Company.

THE PHYSIOLOGY AND PHARMACOLOGY OF THE PITUITARY BODY. By H. B. Van Dyke, Professor of Pharmacology, Peiping Union Medical College, Peiping, China. Cloth. Price $4.50. Pp. 577, with 55 illustrations. Chicago, 1936, University of Chicago Press.

LECTURES ON EMBOLISM AND OTHER SURGICAL SUBJECTS. By Gunnar Nyström, Professor of Surgery, University of Uppsala, Sweden. Cloth. Price $3. Pp. 213, with 66 illustrations. Baltimore, 1936, Waverly Press, Inc.

THE LUNG. By William Snow Miller, Emeritus Professor of Anatomy, University of Wisconsin. Cloth. Price $7.50. Pp. xiv plus 212, with 122 illustrations, 20 in colors. Springfield, Ill., 1936, Charles C. Thomas, Publisher.

Erratum

On page 89 of the January issue, in the article by Scudder, Zwemer, and Truszkowski entitled "Potassium in Acute Intestinal Obstruction," paragraph 2 of the summary should read:

"The potassium rise is ascribed to some combination of dehydration, tissue breakdown, and action of bacterial toxin, with consequent adrenal and renal dysfunction resulting in *inadequate* potassium elimination."